

WATER RESOURCES STUDY

Kennebec River Basin
Maine

Volume I

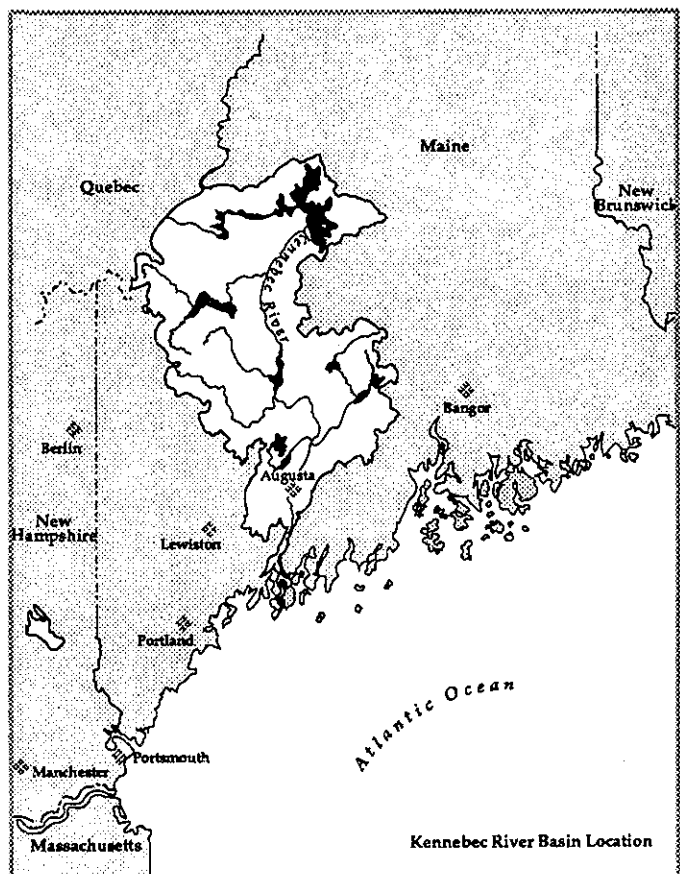
KENNEBEC RIVER BASIN STUDY



February 1990



US Army Corps
of Engineers
New England Division



**WATER RESOURCES STUDY
KENNEBEC RIVER BASIN
MAINE**

February 1990

**Department of the Army
New England Division, Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02254-9149**

EXECUTIVE SUMMARY

This two volume report documents the results of a water resources investigation of the Kennebec River Basin located in west central Maine. Volume II of this report contains copies of the hydrologic, environmental, and economic input to the study. The investigation was authorized by a resolution of the Senate Committee on the Environment and Public Works, adopted 5 May, 1987. In accordance with the authorizing resolution, the investigation focused on determining the advisability of improvements in the interest of flood control, allied purposes and related land resources.

The Kennebec River Basin has a total drainage area of approximately 5,900 square miles, about one-fifth the total area of Maine. The basin is bounded to the north and east by the Penobscot Basin and also forms part of the international boundary between Canada and the United States.

The Kennebec River is subject to frequent flooding as evidenced by four major floods in the last ten years. Flooding usually occurs in the spring as a result of heavy rains in combination with melting snow. In April 1987, such flooding conditions produced flood flows closely approximating a 100-year event. The spring 1987 event is the flood of record for the Kennebec River Basin. Peak flows on the lower mainstem Kennebec and tributaries (Sandy, Carrabassett, and Sebasticook Rivers) ranged 20 to 30 percent greater during the spring 1987 event than the previous record flood of March 1936. The losses to communities in the basin during the 1987 event were estimated by the State at \$34 million.

Due to the large size of the basin and the number of communities involved, it was decided to limit the investigation to communities that experienced \$500K or more in damages during the 1987 event. Limiting the size of the study was necessary in order to provide meaningful information in the short timeframe of the study. The screening process resulted in the selection of fourteen communities for study. Damages in the communities selected account for over 90 percent of the total damages estimated by the State. The communities selected are as follows.

Anson	Hartland	Randolph
Augusta	Hallowell	Skowhegan
Fairfield	Madison	Waterville
Farmington	Norridgewock	Winslow
Gardiner	Pittsfield	

The community of Hartland was not studied further since analysis revealed flood damages were the result of partial failure of a small dam, not overbank flooding. Norridgewock was dropped from further analysis after field investigations revealed only one structure in the 100-year floodplain.

Several alternatives were considered to prevent or reduce flood damages: flood control reservoirs, structural and nonstructural local protection projects, an automated flood warning system for the basin, and the adoption of monthly guide curves for the major storage reservoirs in the upper basin to reduce the effective runoff contributions from these watersheds.

Two flood control reservoir sites were investigated, one on the Sandy River and the other on the Carrabassett River. Results of a economic analysis indicated that the projects were not economically justified. When acting in tandem these reservoirs would reduce total average annual losses in the downstream communities by approximately 77 percent. Although there would be a significant reduction in annual losses, the annual cost of construction far outweighs the expected benefits.

Local protection projects were investigated in the 12 communities selected for plan formulation. The structural alternatives considered consists of reinforced concrete flood walls and earthen dikes. The dikes and walls were evaluated at 50 and 100-year levels of protection. None of the structural alternatives investigated were found to be economically justified.

Nonstructural alternatives consists of a combination of raising structures where possible and installing closures for openings in the flood prone buildings. Nonstructural alternatives were evaluated at a 100 year level of protection. Nonstructural plans were found to be justifiable in six of the twelve communities studied. The six communities are: Hallowell, Randolph, Augusta, Madison, Pittsfield and Farmington.

Results of the investigation show that benefits associated with the proposed automated flood warning system are sufficient to justify the project. An economic evaluation resulted in a benefit to cost ratio of 2.8 to 1.0

In May 1988, the Corps of Engineers completed a hydrologic analysis of flooding in the Kennebec River Basin. This study was conducted under the authority contained in Section 22 of the Water Resource Act of 1972. The study explored the development of reservoir regulation which might further maximize the incidental flood reduction potential of the upper basin storage facilities, without impacting their hydropower functions. The study concluded that the adoption of monthly guide curves for the major storage reservoirs in the upper basin could reduce the effective runoff contributions from these watersheds. Based on that conclusion, reregulation was recommended for additional study to determine the associated benefits, costs and impacts.

Since nonstructural measures involving raising structures and installing closures, an automated flood warning system, and reservoir reregulation appear cost effective and they would normally be recommended for additional analysis in a feasibility study. However, since the estimated Federal portion of the first cost of the various alternatives that were economically justified are well within the \$5 million dollar Federal limit of Section 205 of the 1948 Flood Control Act, as amended, it is recommended that further studies be conducted under this authority.

In a letter, dated December 6, 1989, the State of Maine specifically requested that work continue under the authority of Section 205 of the 1948 Flood Control Act, as amended.

It was, therefore, recommend that no further work be conducted in the Kennebec River Basin under this General Investigation Authority. Any further analysis may proceed under the existing Continuing Authorities Program.

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INTRODUCTION

STUDY AUTHORITY

The Kennebec River Water Resources Investigation was authorized by a resolution of the Senate Committee on the Environment and Public Works, adopted 5 May 1987, which states: "RESOLVED BY THE COMMITTEE ON THE ENVIRONMENT AND PUBLIC WORKS OF THE UNITED STATES SENATE, that the Board of Engineers for Rivers and Harbors, created under Section 3 of the Rivers and Harbors Act, approved June 12, 1902 be and is hereby requested to review the Report on Land and Water Resources of the New England-New York Region printed in Senate Document Numbered 14, 85th Congress, First Session, with particular reference to the Saco River, Kennebec River, and the Penobscot River and their tributaries, Maine, with a view to determining the advisability of improvements in the interest of flood control, allied purposes and related land resources."

STUDY PURPOSE

The study defines water resources related problems and opportunities, identifies potential structural and non-structural solutions, estimates benefits and costs of the alternatives and appraises Federal interest in the potential solutions. The study determines whether or not a feasibility study is appropriate and estimates its costs. Also, a preliminary determination is made of potential impacts on identified significant environmental resources within the study area.

STUDY AREA

The Kennebec River Basin, located in west-central Maine, has a total watershed area of approximately 5,900 square miles, constituting almost one-fifth the total area of the state of Maine. The northwesterly limit of the basin forms a part of the international boundary between the United States and Canada. The basin has a length in the north-south direction of about 150 miles and a width of about 70 miles. Plate 1 illustrates the basin location. The upper two-thirds of the basin, generally above Waterville, is hilly and mountainous, being part of the Appalachian Mountain Range. The lower third of the basin, including the Sebasticook River and Cobbosseecontee Stream tributary areas, has a more gentle topography representative of the coastal area.

The Kennebec Basin encompasses 4 cities, 96 towns, and about 60 unincorporated areas in 2 Congressional Districts. Principal among the population centers are the state capital, Augusta, and the cities of Gardiner, Hallowell and Waterville, all located on the lower mainstem of the Kennebec River as illustrated in Plate 2. These four cities have a population of almost 50,000 which accounts for over 25 percent of the total basin population of 180,000 people (1980 census). The economy of the basin is principally related to forest products, including pulp, paper, paper products and lumber.

There are 17 operating hydroelectric projects within the basin producing approximately 145 megawatts of electric power. The only Federal project in the Kennebec River Basin is a local protection project in the Town of Hartland on the Sebasticook River.

PRIOR STUDIES

NENYIAC Report

A report by the New England - New York Inter-Agency Committee, (NENYIAC), was completed in March 1955. It contains a comprehensive study of overall water resource problems and opportunities in the Kennebec River Basin and identifies potential management plans.

Hydrology Of Floods Kennebec River, Maine

In-October 1985, the Corps of Engineers, New England Division, published a report which reviews and analyzes the hydrology of floods on the Kennebec River. The study was conducted under the authority contained in Section 22 of the Water Resource Act of 1972. The purpose of the study was to review available hydrologic data and analyze the development and component contributions of floods on the river.

Hydrology Of Floods, Kennebec River Basin , Maine Part II

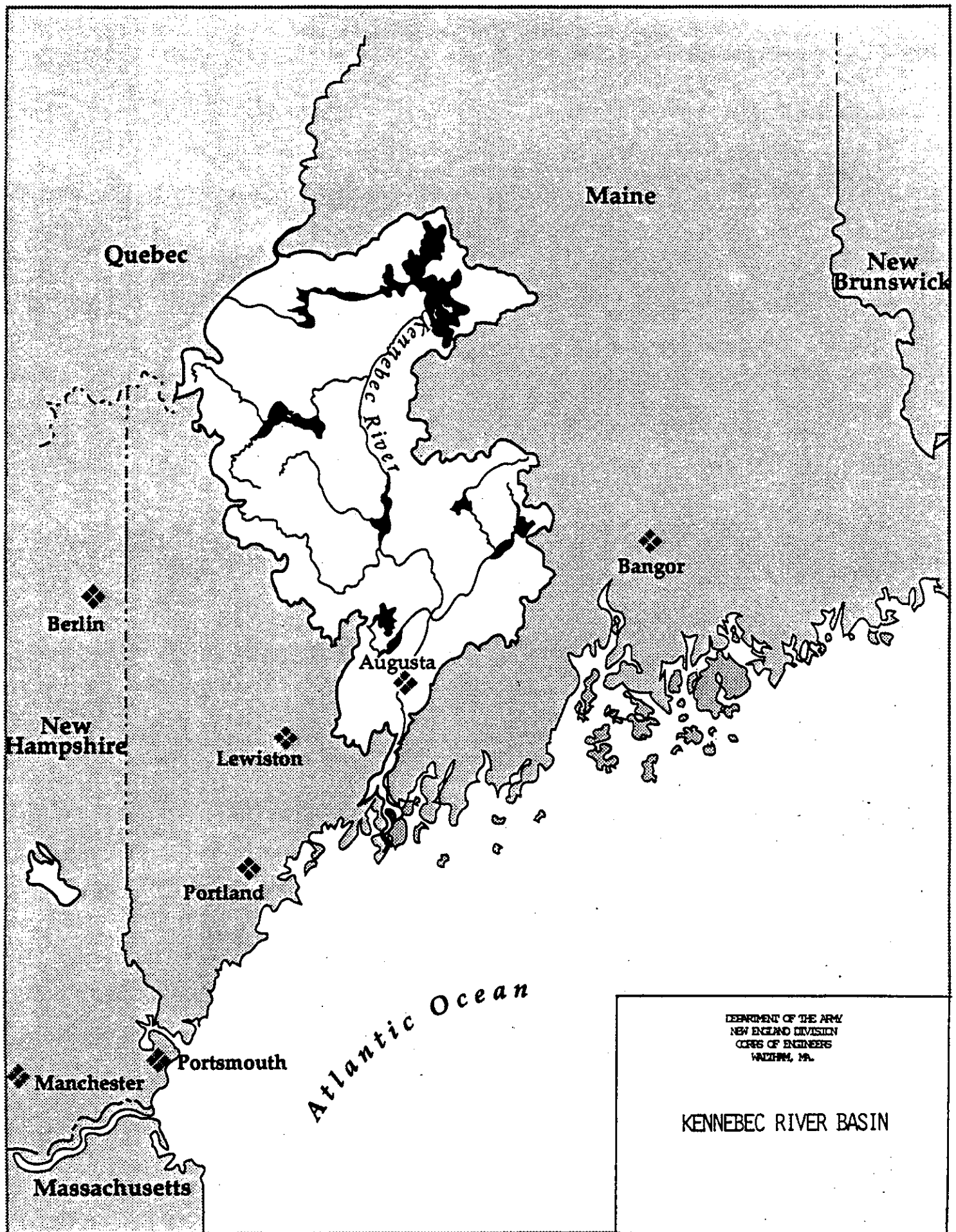
This report presents Part II of a hydrologic analysis of flooding on the Kennebec River Basin. The study was conducted under the authority of Section 22 of the Water Resource Act of 1972. The Part II Study explored the development of reservoir regulation guidance which might further maximize the incidental flood reduction potential of the upper basin storage facilities without impacting their hydropower function.

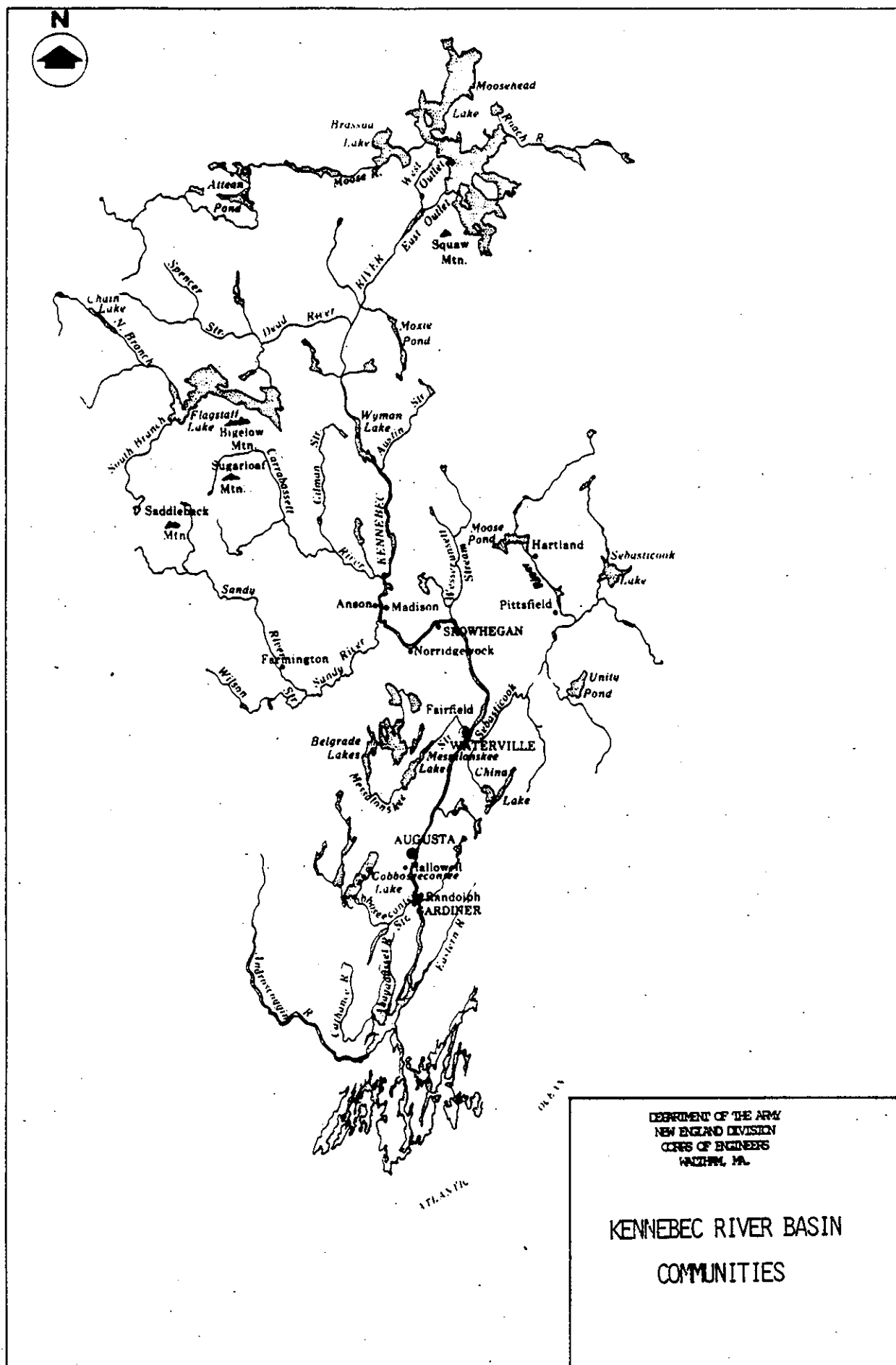
Kennebec River Basin Overview

In December, 1979, the New England River Basin Commission published a report that is intended as a guide for additional planning for the Kennebec River Basin. The report identifies long range priorities for meeting the region's most important natural resource information, planning and management needs.

Flood Insurance Studies

Flood insurance studies have been prepared by FEMA for many communities in the Kennebec River Basin.





DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WASHINGTON, D.C.

Kennebec River Basin Communities

State Of Maine 1988 Water Quality Assessment

This report was prepared by the Maine Department of Environmental Protection, Bureau of Water Quality Control. This biennial report to the U.S. Environmental Protection Agency describes the quality of its navigable waters.

EXISTING CONDITIONS

PHYSICAL RESOURCES

Watershed Description

The Kennebec River basin, located in west central Maine, has a total drainage area of approximately 5,900 square miles, constituting almost one-fifth the total area of the State of Maine. The Androscoggin River basin lies to the west, the Penobscot River basin to the north and east, and a section of the Maine coastal area to the south. The northwesterly limit of the basin forms a part of the international boundary between the United States and Canada. The basin has a length in the north-south direction of about 150 miles and a width of about 70 miles. The upper two-thirds of the basin, generally above Waterville, is hilly and mountainous, being part of the Appalachian Mountain Range. The lower third of the basin, including the Sebasticook River and Cobbosseecontee Stream tributary areas, has a more gentle topography representative of the coastal area. A map of the Kennebec basin is shown on Plates 1 and 2.

Kennebec River

The Kennebec River originates at the outlet of Moosehead Lake and flows southerly 145 miles to the head of Merrymeeting Bay at Abagadasset Point, about seven miles above Bath. From Merrymeeting Bay the Kennebec waters continue south, through the Maine coastal area, another 20 miles to the Atlantic Ocean at Hunniwell Point. The main river is tidal as far as Augusta, 25 miles above Abagadasset Point. Between its origin and mean tide at Augusta, the river falls about 1,026 feet in a distance of 120 miles, an average gradient of 8.5 feet per mile. One "S" curve in the river, between Madison and Skowhegan, forms the only large digression in the river's southward course.

Tributaries

The principal headwater tributary is Moose River which drains 722 square miles of mountainous watershed area easterly to Moosehead Lake. The tributary area of the Moose River represents about 58 percent of the total Moosehead Lake watershed (1,268 square miles). The Moosehead Lake watershed, in turn, represents about one-fifth (20 percent) of the total Kennebec basin area.

Principal downstream tributaries (400 or more square miles) are the Dead, Carrabassett, Sandy, and Sebasticook Rivers. Individual drainage areas are listed in table 1. The combined drainage area of the four principal downstream tributaries are about 2,800 square miles, representing 47 percent of the total basin area and about 60 percent of the area below Moosehead Lake.

Flagstaff Reservoir, another large regulated lake, is located in the Dead River tributary watershed. The Carrabassett and Sandy Rivers are hydrologically flashy, draining unregulated mountainous terrain, whereas, the Sebasticook River drains flatter more hydrologically sluggish terrain.

**TABLE 1
KENNEBEC RIVER
PRINCIPAL TRIBUTARIES**

<u>Tributary</u>	<u>Drainage Area</u> (sq miles)	<u>Length</u> (miles)	<u>Fall</u> (ft)
Moose River	722	76	750
Dead River	867	23	570
Carrabassett River	401	35	636
Sandy River	596	69	1544
Sebasticook River	946	48	270

Dams and Reservoirs

There are 17 hydroelectric dams in the Kennebec River basin with ten located on the main stem Kennebec and having 95 percent of total generating capacity in the basin. Dams on the main stem harness approximately 50 percent of the total fall of the river. All hydropower dams are run-of-river except Harris (Indian Pond) and Wyman which have storage capacity only for daily or weekly load fitting operations.

There is a total of about 1,300,000 acre-feet of reservoir storage in the Kennebec basin, used for hydropower regulation, with about 86 percent of that storage located in the upper 46 percent of the watershed, upstream of Bingham, Maine. The other 14 percent is generally distributed between the Sebasticook, Messalonskee, and Cobbosseecontee tributary watersheds in the lower part of the basin below Waterville. Available reservoir storage in the upper basin has a marked effect on upper basin floodflow contributions to the Kennebec River. Principal storage reservoirs in the basin above Bingham are listed in Table 2. There are 1,132,000 acre-feet of storage in the upper basin and 1,016,500 acre-feet, or 90 percent at the three lakes: Brassua, Moosehead and Flagstaff.

TABLE 2

**AVAILABLE RESERVOIR STORAGE
KENNEBEC RIVER BASIN ABOVE BINGHAM, MAINE**

<u>PROJECT</u>	<u>DRAINAGE AREA</u> (Sq. Mi.)	<u>FULL POOL SURFACE AREA</u> (Acres)	<u>DRAWDOWN</u> (Feet)	<u>STORAGE</u> (Ac-ft)	<u>PERCENT</u>
Brassua Lake	710	8,979	30	196,500	17
First Roach Pond	63	3,270	7	21,500	2
Moosehead Lake	1,268	74,000	7.5	544,000	48
Indian Pond (Harris)	1,355	3,747	5	19,000	2
Moxie Pond	80	1,747	8	14,700	2
Flagstaff Lake	520	17,950	35	276,000	24
Wyman Lake	2,595	3,145	20	<u>60,300</u> 1,132,000	<u>5</u> 100

Climatology

The Kennebec River Basin has a cool semi humid climate characteristic of northern New England. The summers are cool and the winters severe, particularly in the mountainous regions in the upper watershed. Average annual temperature is about 42 degrees F. Average monthly temperatures vary from 65 to 70 degrees F in July to 10 to 20 degrees F in January and February. Coldest temperatures occur at the higher elevations on the northwesterly side of the basin. Extremes in the temperature range from 90 to minus 30 degrees F.

Average annual precipitation over the basin is about 42 inches occurring quite uniformly throughout the year. The area experiences periods of moderate storm rainfall as a result of low pressure systems moving up the east coast and from frontal systems moving from west to east across the country. Periods of moderate storm rainfall are usually not more than 1 to 2 days in duration. Storm rainfall amounts of 2 to 4 inches are relatively common but events of 6 inches or more are rare. Due to its northerly location, the basin has escaped thebrunt of coastal

hurricanes with their accompanying intense rainfall. Much of the precipitation during the winter months occurs as snow with average annual snowfall ranging from about 65 inches along the coast to about 120 inches in headwater areas. The average water equivalent of the snowpack in the spring generally ranges from 5 to 8 inches with over 12 inches common in the upper interior areas of the watershed. During the spring months, March through May, the melting snowpack, independently or in combination with rainfall, is a prime producer of floods in the Kennebec basin.

Geology

Maine is a glaciated rock-controlled terrain consisting of a mountainous region in the northern part and a rolling low-lying coastal area. The bedrock geology of Maine is a complex arrangement of pre-dominantly metamorphosed sedimentary rocks, plutonic rocks and volcanic rock types. Plate 3 shows the major structural features consisting of synclines (troughs) and anticlines (arches), and a major fault zone. The features are strongly aligned in the northeast-south west direction. They are the result of a long and complicated sequence of regional dynamic geologic events that include sediment deposition and rock formation, igneous activity, folding, faulting and erosion. During the last episode of continental glaciation, Maine was covered by extensive ice sheets. During periods of advancing ice, rock surfaces in some places were scoured and valleys deepened. In other places, deposits of till were laid down. Retreating glaciers left a variety of surficial unconsolidated deposits. The glacial ice was so extensive that the land subsided and there were inland inundations of the sea. Marine deposits are found far inland in the Kennebec River Valley.

Bedrock Geology

Plate 4 shows the Kennebec River Basin located on a simplified geologic map of Maine. The major rock types in the basin are meta-sedimentary, plutonic, and volcanic types. The plutonic and volcanic rocks are more resistant to erosion and form the ridges and peaks throughout the basin. Modern drainage patterns and locations of lakes are controlled by topography largely influenced by bedrock.

Surficial Geology

The Kennebec River Basin is covered by various surficial materials of glacial origin. The last ice sheet completely covered the area and extended into the Gulf of Maine. Plate 5 shows the interpreted positions of the ice margins during various stages of retreat. Rock and soil picked up by the ice was deposited as till both during advance and retreat of the glaciers. Till is a heterogeneous mixture of particles from clay to boulders in size generally with low permeability. It is found throughout the basin at all elevations. At higher elevations it is usually at the surface directly overlying bedrock. At lower elevations and in valley bottoms it may be buried by subsequent water-laid deposits.

During deglaciation, meltwaters caused the deposition and formation of a variety of topographic features primarily at lower elevations at the sides of hills and in valleys. Sands and gravels generally are found in numerous landforms including kames, eskers, terraces, deltas

and outwash plains. Fine-grained sediments are found where lakes once stood.

Geologic literature indicates the glacial ice was so extensive that it depressed the land several hundred feet. Marine waters invaded the lowlands and extended into the interior of Maine. Deposits of gray marine fine-grained sediments, known as the Presumpscot Formation, are found extensively in the valleys of Kennebec Basin as far north as New Portland. The formation is commonly a clayey silt but may be mostly sand in places. The marine deposits also have coarse phases where, locally, sand and gravel dominate. The Presumpscot Formation may be up to 100 feet thick in places. It usually lies over till or sands and gravels but it may also be interbedded with or overlain by sands and gravels.

There are many areas of extensive urban development and growth in the valleys and the local surficial geology has been a major influence on the local character of urban development. The character and distributions of surficial materials are important factors in development because of favorable water resources, foundations and economic materials such as sands and gravels. Areas in and adjacent to flood plains are commonly developed with extensive fills placed to extend usable land in desirable areas as well as barriers and protection against flooding and erosion. The availability of suitable earth materials for construction is also a consideration in project economics.

The Kennebec River Basin is in Zone 2 on the seismic zone map of the Department of the Army, U.S. Army Corps of Engineers Engineering Regulation 1110-1-1806. This is a zone of moderate potential damage from earthquakes. Seismic activity primarily affects the walls of structures. Retaining walls should be designed against an earthquake acceleration of 0.10g.

ENVIRONMENTAL RESOURCES

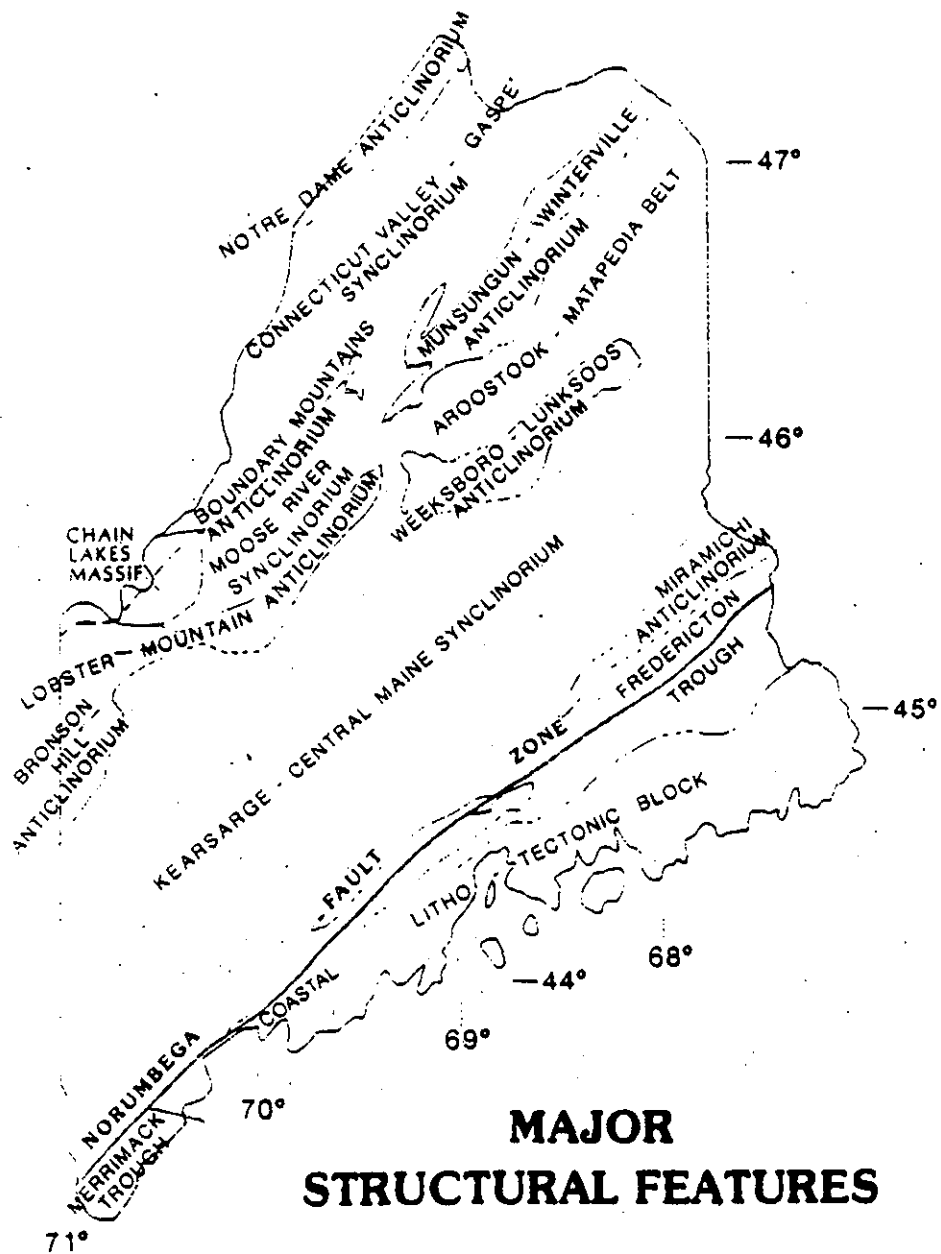
Water Quality

The waters of the Kennebec are designated Class B above Skowhegan dam and designated Class C from Skowhegan down to Merrymeeting Bay. The sections of the Carrabasset River above North Anson are designated Class A and B; sections below North Anson are classified as Class C waters. The sections of the Sandy River above Farmington are designated Class A and B, the section below Farmington is classified as Class C waters. The Sebasticook River receives Class B and C ratings. Cobbosseecontee Stream also receives Class B and C ratings.

The State of Maine Water Quality Classification for stretches of the Kennebec River, Carrabasset River, Sandy River, Sebasticook River and Cobbosseecontee Stream are listed in the Environmental Considerations Section, Volume II of this report.

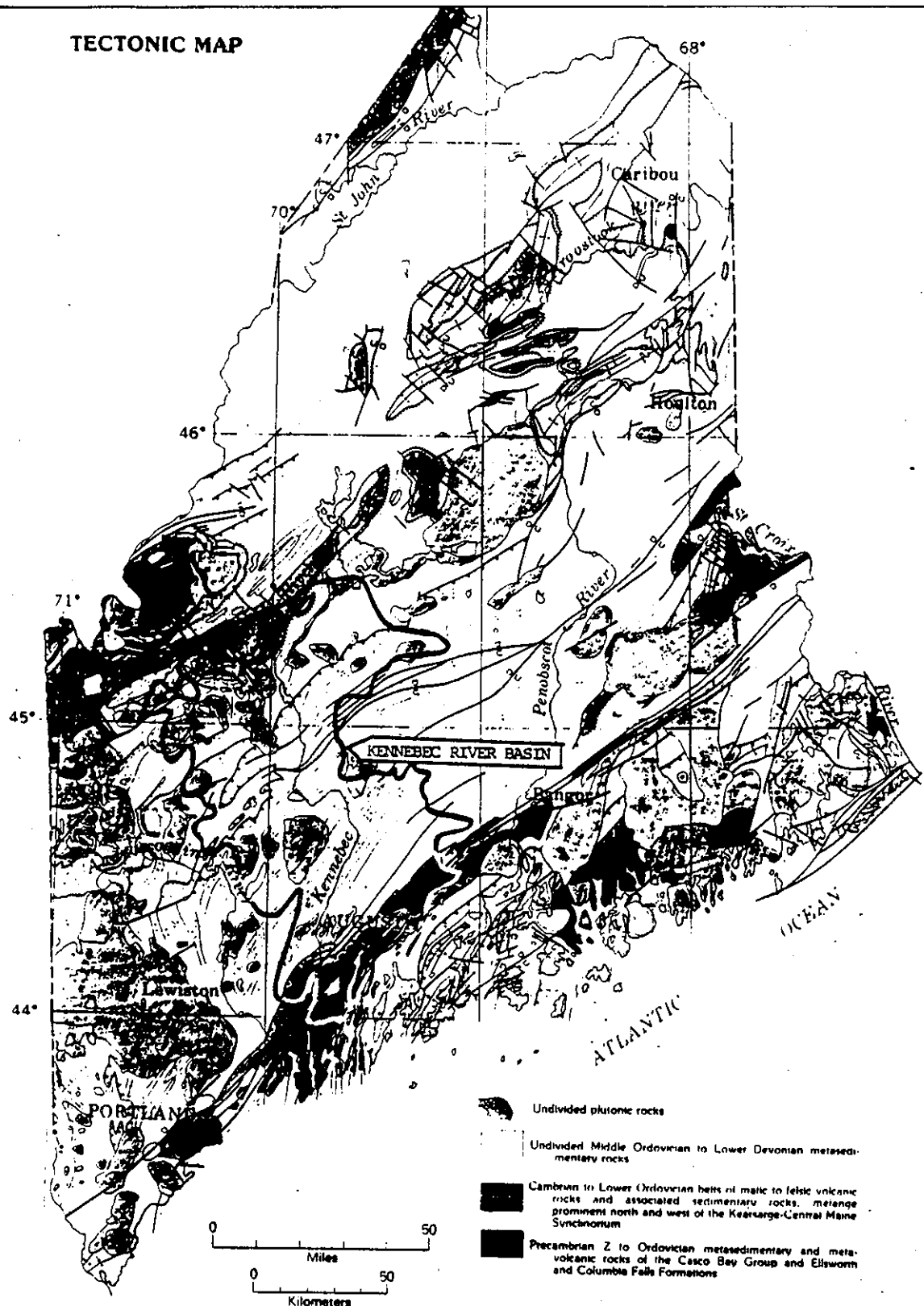
Biological Resources

The larger northern basin is mostly spruce-fir forests whereas the coastal uplands of the lower basin are more rural. Timber harvesting and seasonal recreation are the mainstay of the economy in the northern basin. The lower portion of the Kennebec River basin has some of the



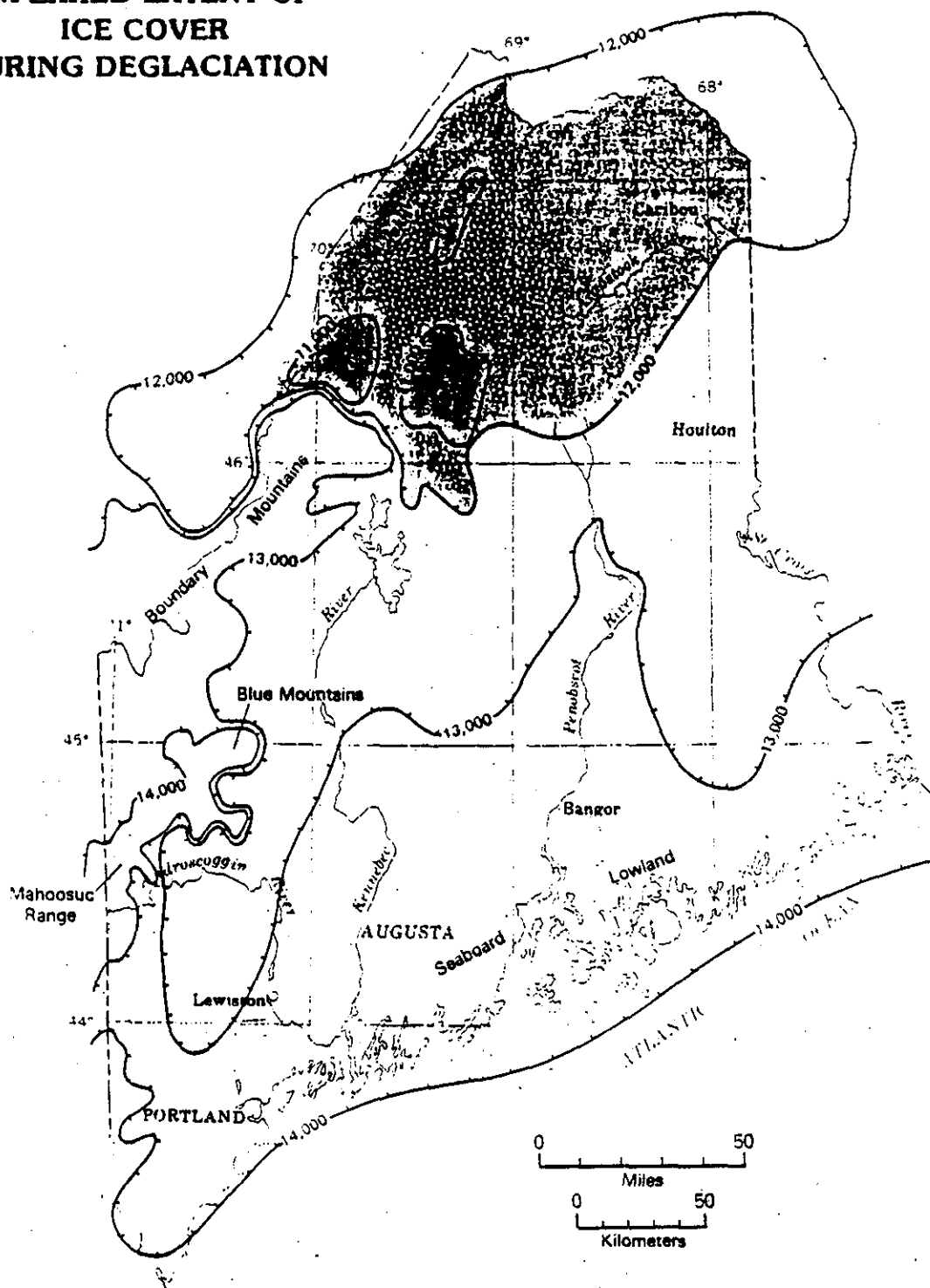
Adapted from "Bedrock Geologic Map
of Maine", Maine Geological Survey, 1985

TECTONIC MAP



Adapted from "Bedrock Geologic Map of Maine", Maine Geological Survey, 1985

INFERRED EXTENT OF ICE COVER DURING DEGLACIATION



Map shows successive positions of the late Wisconsinan ice margin in Maine from 14,000 to 11,000 years ago (adapted from Davis and Jacobson (37) and Denton and Hughes (38)). Extent of ice cover is based on limiting radiocarbon dates, inferred ice-surface gradients, and topography. Number and configuration of ice remnants at 11,000 yr B.P. are conjectural. Only the outer limits of essentially continuous ice cover are shown here, without implications regarding ice dynamics. Some mountainous areas that locally protruded through the thinning ice sheet are omitted. Darker colors show progressively later areas of ice cover.

Adapted from "Surficial Geologic Map of Maine",
Maine Geological Survey, 1985

States best agricultural and dairy land.

Habitat types include forested uplands, forested wetlands, shrub-scrub wetlands, both persistent and non-persistent emergent wetlands, and open fields.

Bird species in the area include spotted sandpiper, great blue heron, mallard, black duck, common merganser, double-crested cormorant, herring gull, black-backed gull, belted kingfisher, common loon, American robin, song sparrow, yellow warbler, yellow-rumped warbler, winter wren, cedar waxwing, ruffed grouse, red-tailed hawk and kestrel.

Lists of vertebrate species likely to be found in the project area were compiled as part of the FERC licensing for the Williams Dam (CMP, 1986). A list of freshwater and anadromous fish in the Kennebec River Drainage and a list of mammals whose geographic range includes the project area are in the Environmental Considerations Section of Volume II. A list of amphibians and reptiles whose range encompasses the project area can also be found in Volume II.

Threatened and Endangered Species

Bald Eagles (Haliaeetus leucocephalus) nest and overwinter at a number of sites along the Kennebec, especially the lower sections of the river. Impacts to Bald Eagles are of particular concern in the Augusta area and south (Augusta, Hallowell, Gardiner, Randolph) and around the confluence of the Sebasticook and Kennebec rivers (Winslow and Waterville)

Shortnose sturgeon (Acipenser brevirostrum) which inhabit the Kennebec River south of Augusta are Federally listed as an endangered species. The Shortnose sturgeon is an anadromous fish. The high flows and narrow channel provide spawning habitat for the adults which spawn in the spring (April - June). A section 7 Endangered Species consultation would be required for parts of the project below Edwards Dam in Augusta which might involve activity in the water.

Piping plover (Charadrius melodus) nest and feed on coastal beaches. The towns of Gardiner and Randolph represent the southern extreme of the project and therefore would not impact piping plover habitat.

The small Whorled Pogonia (Isotria medeoloides) is an endangered plant species which occurs in Kennebec County. This plant favors the acidic soil of dry woods and is not likely to be found near the river.

HISTORIC AND ARCHAEOLOGICAL RESOURCES

Prehistoric Period

Information about human habitation in the Kennebec River Basin in prehistoric times (10,500 B.C. to A.D. 1600) is fragmentary, but we can draw some inferences from the existing data. More information about prehistoric site location has been collected within the last three

years, but is not yet generally available. As this data becomes available, a more complete picture of prehistoric human use of the basin will be possible.

During the sixteenth and seventeenth centuries, European explorers and colonists encountered many native peoples in the Kennebec River Basin. The Jesuits established missions during the seventeenth century at several locations along the river, including Norridge-wock, and another three miles above Fort Western (Augusta). Charles Nash, in his 1892 work "Indians of the Kennebec" reports that the groups encountered by the first European settlers were nomadic to semi-sedentary peoples, tarrying "according to their moods or circumstance for days or weeks at sundry places- at the mouths of tributary streams and at the falls where the migrating sea fishes congregated in great numbers during their passage to their native beds. These general migrations sometimes extended to the sea, but usually no further than Merry-meeting Bay, where other tribes assembled, and all had a merrymeeting." Accounts from Jesuit priests and other early travelers provide details of the movements of groups across the landscape. In most accounts, the river plays an important role as a transportation route, and a source of food (e.g. migrating fish runs).

The groups encountered by the Europeans were the last in a long line of peoples exploiting the resources of the Kennebec River Basin. The earliest are referred to as Paleoindians. Their sites date from approximately 10,500 B.C. to 8000 B.C., and are recognized by the distinctive stone tool assemblage, which include fluted projectile points. Paleoindians lived in a cold, tundra or spruce parkland environment, and hunted large animals such as caribou. The Archaic period (6000 B.C. to 1500 B.C.) is divided into Early (8000 B.C. to 6000 B.C.), Middle (6000 B.C. to 4000 B.C.) and Late, or Terminal (4000 B.C. to 1500 B.C.), and are characterized by distinctive projectile point styles and tool assemblages. The Woodland, or Ceramic period (1500 B.C. to A.D. 1600) is also divided into Early (1500 B.C. to 300 B.C.), Middle (300 B.C. to A.D. 1000) and Late (A.D. 100 to A.D. 1600), and are distinguished by projectile point styles and ceramic styles, as well as mortuary traditions.

Very few Paleoindian sites have been identified in Maine. For the most part, they are on higher terraces, or high outwash plains. For the Archaic and Woodland (Ceramic) periods, and even the early historic (1600 - 1750), several sites have been identified along the Kennebec River. Many of these sites have been identified within the last three years during surveys for hydro-power re-licensings. The number of sites identified along the river is multiplying on a nearly geometric scale, due to these large survey projects. Some sites are single-component, that is, they contain artifacts from a single time period. Other sites apparently were used repeatedly for centuries or millennia, as they contain evidence from several different time periods.

Prehistoric archaeological sites may be present on many different landforms within the riverine environment. Concentrations of sites occur at tributary stream junctions and falls, but the floodplains and river terraces also may have sites, although some may be buried by alluvial sediment. The Maine Historic Preservation Commission's files contain records of several prehistoric sites in close proximity to nearly all current study areas. Evidence of prehistoric occupation has been unearthed even in urban areas, such as Augusta and Winslow. The currently known inventory of sites suggest that the River Basin has received nearly continuous use as a habitation/resource exploitation area for at least the past 6000 to 8000 years. Any structural alternative has the potential for disturbing previously unidentified prehistoric sites.

Close examination of the geomorphology and compilation of the land use history for the last 350 years will be required before structural alternatives are authorized for construction.

Historic Period

The Kennebec River was the major transportation route for the river towns for most of the 18th and 19th centuries, and for that reason settlement mainly occurred along the river's edge. The river carried lumber, freight and passengers. The Kennebec was the focus of the towns until the Portland and Kennebec Railroad Company began operation in the 1850s. The railroad provided a ready access to Boston and Portland markets and stimulated the industrial development of the region. Dams were constructed to power the mills built along the river banks, and towns like Hallowell, Gardiner and Skowhegan became thriving commercial centers.

Augusta

The first trading between the Abenaki Indians of the Kennebec and the Pilgrims of Plymouth Colony began in 1625. Edward Winslow travelled up river and traded corn for beaver pelts. This and later trips were so successful that within three years Plymouth Colony was granted exclusive rights to trade on the Kennebec, the ownership of lands on both sides of the river and the right to install a local government. A permanent trading house was built near the site of the present Fort Western in Augusta. This became known by the Indian name of Cushnoc.

Trade declined in the 1640s due to Mohawk raids on Abenaki hunting grounds. In 1652 the Plymouth grant was enlarged to include land on the lower Kennebec and Merrymeet-Bay. Plymouth Colony sold the Kennebec Patent in 1661. The new Kennebec Proprietors attempted to revive trade in the area, but were unsuccessful, so the area was abandoned. The patent was not reestablished until 1749.

In 1749 the heirs of the Kennebec Proprietors incorporated as "The Proprietors of the Kennebec Purchase from the late Colony of New Plymouth". Settlement did not begin however until 1754. In that year there were Indian raids on Fort Richmond, south of the Kennebec Patent, and rumors that the French were building a fort on the upper Kennebec. Governor Shirley of Massachusetts sent 800 militia to build forts at Cushnoc and what is now Winslow. Fort Western and Fort Halifax were built at these sites.

In 1761 a survey was made of the Augusta-Hallowell area and in 1762 the permanent settlers arrived. Seven log huts were built and 30 people spent their first winter in the region. By 1764, 37 lots had been sold, ten were occupied and there were 100 settlers in the vicinity of Fort Western. Settlement proceeded very slowly due to its inaccessibility. There were no roads aside from the military road between Fort Halifax and Fort Western, no schools or meeting house and the only gristmill was located downstream at Gardinerstown (Gardiner). The main business at this time was fishing and trade with the Indians.

The town was incorporated on 26 April 1771 and named Hallowell after one of the proprietors, and became a town of Lincoln County. The town encompassed roughly 90 square

miles and included all of the present Augusta, Hallowell, Chelsea and part of Manchester and Farmingdale.

The first sawmill in Hallowell (Augusta) was erected in 1769 by Captain James Howard. Captain Howard bought 900 acres of the Kennebec grant including Fort Western and built the sawmill and the first wood frame structure house in the settlement.

In 1775 the Arnold Expedition stopped at Fort Western on their way to Quebec. General Benedict Arnold led an army of 1100 Revolutionary soldiers up the Kennebec Valley by boat for an attack on Quebec. It was hoped that by gaining control of this British stronghold the war would be shortened. The expedition left Fort Western after nine days of preparation, and after suffering great hardship on their trip, were defeated in their assault on Quebec.

The Kennebec settlements had a difficult time obtaining provisions during the war. British ships along the Maine coast disrupted the fishing and lumber trade. Shipping was curtailed and there were food shortages.

The population in the District of Maine nearly doubled after the Revolution. Massachusetts soldiers returning from the war found that land in Maine was cheap and plentiful. One hundred to 160 acres at no more than \$1.50 an acre was the usual grant to private soldiers. In 1775 there were only 34 incorporated towns in Maine. By 1790 the number of towns increased to 72. In 1790 the population of Augusta-Hallowell was 1,914, an increase from 692 in 1784.

The 1790s were a time of prosperity for the Kennebec Valley. Hallowell profited by the increase in the American shipping trade. In 1790 the total shipping of the town was estimated at 500 tons.

Industrial activities included two gristmills, five sawmills, two slaughterhouses and a bakery. Lumbermen and farmers had increased markets for their products. The farmers raised beef, pork, potatoes, beans and hay for the lumber camps. Augusta-Hallowell was the market for farm products and imported goods. Sheep, cattle and other products were shipped to the coast by way of the Kennebec River.

Hallowell was developing into two prosperous and rival settlements, Fort Western (Augusta) and the Hook (present day Hallowell). Each settlement had its own meeting house, post office, ferry and newspaper. When a charter for construction of a bridge across the Kennebec was granted to the Fort settlement, the rivalry increased until on 20 February 1797 the Massachusetts legislature divided Hallowell into two separate towns, Hallowell and Harrington. On 9 June 1797 Harrington changed its name to Augusta.

Kennebec County was established in 1799, with Augusta as its shire town. The new courthouse was completed in 1802. By this time the population was 1,216. In 1806 Colonel T.S. Estabrook started the first stage coach service to Augusta. The stage travelled bi-weekly between Augusta and Brunswick, Maine.

The "Malta War" began in 1808. This disturbance began with a dispute over land titles in the Kennebec Valley, and escalated when the Augusta jail was burned and the courthouse was almost set afire. The dispute was settled when seven persons arrested in the disturbance were tried and acquitted. In 1808 the Betterment Act was passed to appease the squatters and lessen confusion over titles for land. This led to increased settlement in the Kennebec region.

The population of Augusta in 1810 was 1,805. At this time, the town had 39 shops, 6 offices, 11 sawmills, 3 gristmills and 168 homes. Augusta was shipping over 282 tons annually by way of the Kennebec River. Business and trade however were seriously effected by the embargoes in force during the War of 1812. During the war all the stores but one in Augusta were forced out of business.

In 1820 Maine became a state independent of the State of Massachusetts. On 24 February 1827 an act was signed making Augusta the capitol of the state, and on 4 July 1829 the cornerstone was laid for the capitol building which is still in use.

The first dam on the Kennebec River in Augusta, was completed in 1837 by the Kennebec Dam Corporation. By 1846 there were six sawmills, a large flour mill and a cotton mill in operation at the dam.

Extensive transportation routes were established in the Kennebec Valley during the 19th century. The first regular steamboat service between Boston and the Kennebec ports was inaugurated in 1836. The railroad line from Portland to Augusta, the Kennebec and Portland Railroad Company, opened in 1851. The Augusta, Hallowell and Gardiner trolley began service in 1890, and ran until 1932 when buses replaced the electric cars.

By 1900 the population of Augusta was 11,683. An attempt was made in 1907 to move the state capitol to Portland but this was unsuccessful. In 1911 the state legislature adopted an act declaring Augusta to be the permanent seat of government.

Fort Western is one of the oldest colonial buildings in America. The only original component of the site is the former officers quarters. The area, however, is also significant as an archaeological site. Fort Western was restored in the 1900s and is now in use during the summer as a public museum. The fort has been designated a National Historic Landmark.

Hallowell

On 20 February 1797 Hallowell was divided into two separate townships, Hallowell and Augusta. The new smaller town of Hallowell prospered and by 1807 had secured most of the trade from the western agricultural towns and had extended its influence to the seaboard towns as well. Hallowell became second only to Portland as a market town. The embargoes and the War of 1812 did extensive damage to Hallowell as a center of trade but it quickly recovered after the war and became the site of various new industries as well.

In 1820 Hallowell had a population of 2,919, and was once again a thriving river port and market town. Shipbuilding was an important industry. At least eight ships were built

in Hallowell prior to 1820. Shipbuilding declined with the arrival of the steamboat and the last sailing ship built in Hallowell was completed in 1856.

In 1826 the Kennebec River ice industry began. This business lasted for 75 years. Icehouses were present all along the river north and south of the town for about 20 miles. The ice was shipped to the West Indies, Europe and the southern states.

Lumbering operations continued to be an important industry in Hallowell throughout the 19th century. On 29 March 1836 the Hallowell Steam and Boom Company was incorporated. Log-driving companies ran their logs down river to Hallowell which had the largest sorting boom for the mills farther down stream. This occupation employed 300-400 people.

The Kennebec and Portland Railroad reached Hallowell in 1851. The railroad soon had branch lines constructed to many of the small western towns. Hallowell's importance as a market town and trade center sharply decreased with this convenient outlet to the larger markets of Boston and Portland readily available to the agricultural towns.

Granite quarrying became a major industry in Hallowell by the end of the 19th century. The business began as early as 1815, with small crews cutting stones for a Boston market for granite cornerstones. The first building to be constructed entirely of Hallowell granite was the capitol building in Augusta erected in 1829. By 1897 the industry employed 500 people in Hallowell. Artisans emigrated from Europe to perform the master carving of statues and other granite structures. The industry declined between 1910 and 1930 due to a decrease in demand for Hallowell-type granite.

Other major industries located in Hallowell during the late 19th and the early 20th centuries were a shoe manufacturer, an oilcloth factory and a cotton mill. With the decline of Hallowell's importance as a trade center, the various industries became the main economic base for the town.

The production of H.P. Clearwater's patent medicines under the name of the Heart Cure Co. and Joint-Ease was a major business from the early 1900s to 1952. Mr. Clearwater's medicines were distributed throughout the United States, Europe and Africa, and he employed over 100 people in Hallowell.

The City of Hallowell has a historic district listed on the National Register of Historic Places. The district is comprised of 450 buildings of public, private, commercial and industrial use. The district encompasses the entire downtown area and includes Water Street, adjacent to the Kennebec River. The district is significant because it retains the architectural integrity of Hallowell as it was when the town was a prosperous 19th century river port.

Winslow

Winslow is situated at the junction of the Sebasticook River with the Kennebec River. It was first known as Ticonic. In 1649 Kennebis, an Indian chief, conveyed the land on the Kennebec River to Christopher Lawson. A trading house was built in the area in 1653, by Lawson and assigned to two traders, Clark and Lake. By 1675 there were two trading houses

at Ticonic, Clark and Lake's and the other operated by Richard Hammond. In 1676, during King Philip's War (1675-1676), the trading houses were captured and Lake and Hammond were killed by the Indians. Ticonic was not resettled until the 1750s, when there was no longer any threat of Indian raids.

In 1754, in order to protect the Kennebec Valley from the French, a series of forts were built along the river. Fort Halifax was erected on the fork of land formed by the junction of the Sebasticook and Kennebec Rivers. This area was selected by General John Winslow under the direction of Governor Shirley. Fort Halifax was manned by a garrison of 100 men under the command of Captain William Lithgow.

The first farmer at Fort Halifax was Morris Fling, who cleared the flat land around the fort which became known as Fling's Interval, in 1764. Little settlement occurred in the area until after the town of Winslow was incorporated on 26 April 1771. The town was named in honor of General John Winslow and included what is now Waterville and Oakland.

The settlement at first clustered around the fort. The first tavern in Winslow, run by Ezekiel Pattee, was located in Fort Halifax as were the trading houses of Arthur Lithgow and Richard Thomas. Thomas lived at the fort until he built the second tavern in Winslow, the Halifax House in 1798. This tavern was located between the fort and the Kennebec River.

The first saw and gristmill in Winslow was built before 1770 by the Kennebec proprietors to encourage settlement. In 1780 two other saw and gristmills were established by Stephen Crosby and Dr. John McKechnie. These were built on the Pattee and Messalonskee Brooks.

The town of Waterville was incorporated as a separate township on 23 June 1802. The town encompassed all land from the Winslow township located on the western bank of the Kennebec River. With no bridge to connect the two settlements until 1824, the towns had developed as two distinct areas and separation became inevitable.

Most industries in Winslow during the 19th century were small mills with a single owner and employing only a few persons. There were numerous saw and gristmills, as well as a hemp mill, shoe peg factory, woolen mill and plaster mill. Most were located on small streams such as Pattee, Messalonskee and Drummond Brooks. There were several clay beds near the Kennebec River which were used for brickmaking.

Two large mills were constructed in Winslow in the 1890s. A large steam saw mill was situated near the old Fort Halifax. This mill employed sixty five men and cut one million feet of lumber per month as well as 3,000,000 shingles. The largest pulp and paper mill in Kennebec County was built on the east bank of the Kennebec by the Hollingsworth and Whitney Company in 1892. A dam was built across the river and a canal was dug. The mill converted 6,000,000 feet of lumber per year into pulp and produced 24 tons of manila paper per day.

The Fort Halifax blockhouse, the fort's only surviving structure, is a National Historic Landmark. The blockhouse, built in 1754, is the oldest in the United States. The fort

was the most northerly Anglo-American Kennebec fort. The blockhouse was washed away in the 1987 flood. Some timbers were returned from downstream and the blockhouse has been reconstructed. The Fort Halifax blockhouse is currently maintained by the Maine Bureau of Parks and Recreation.

Waterville

The town of Waterville was part of Winslow until its incorporation as a separate township on 23 June 1802. Waterville was incorporated into a village on 13 September 1830.

Waterville developed into a major shipping town during the 19th century. The town's primary business at this time was lumbering. The smaller streams supported numerous sawmills, and woodworking factories. Other industries included a match factory, a woolen mill, tanneries, brick yards and a shovel handle factory.

The first dam built on the Kennebec was erected in 1792 from the west bank to Rock Island. Several sawmills were built there and until 1850 this area was the manufacturing and business center of the town.

The major transportation corridor during the early 19th century was the Kennebec River. Many steamers anchored at Waterville and in 1848 alone, there were five steamers daily between Waterville and Augusta. However, with the opening of the Androscoggin and Kennebec Railroad to Waterville in 1849, river traffic drastically decreased.

In 1866 the Ticonic Water Power and Manufacturing Company was incorporated. The company acquired the water rights and property adjacent to the Ticonic Falls on the Kennebec River. In 1868 a dam was built and in 1874 the Ticonic Power Company became the Lockwood Company. The Lockwood Company began spinning cotton in 1876. By 1892 the mills employed 1250 people and produced 8,752,682 yards of cotton cloth.

Waterville in the 20th century still contains several large industries. The C.F. Hathaway Company employs over 1000 people in the manufacture of menswear and the Keyes Fibre Company is the world's leading molded pulp company.

The Two Cent Bridge, a footbridge spanning the Kennebec River, linking Waterville and Winslow, is listed on the National Register of Historic Places. The bridge is a small steel suspension bridge, is 700 feet long and was built in 1903. It is the last private toll footbridge in the United States.

Gardiner

The Gardinerston plantation, originally part of the Kennebec Patent, was incorporated as the town of Pittston in 1779. In 1803, the territory lying on the west side of the Kennebec was incorporated into a separate town. The town was named Gardiner after Dr. Sylvester Gardiner, a Boston land speculator, and one of the original proprietors. By 1770, Dr. Gardiner owned over 12,000 acres as well as the water privileges for the Cobbosseecontee Stream.

The Cobbossee mill, the first gristmill in Kennebec County, was constructed by Dr. Gardiner in 1761 on the Cobbosseecontee. Free public schools were established in 1784 and one of the first post offices in the county was established in Gardiner on 1 November 1795.

Gardiner developed into a thriving river port and industrial center during the 19th century. The town's industrial development occurred as a result of the waterpower of the Cobbosseecontee Stream.

The first dam on the river (Dam No. 1) was built in 1761, by Dr. Gardiner, to power a saw and gristmill. By 1800 there were 13 sawmills in operation at the dam. There was also a foundry, a machine shop and a lead pipe works. Until the 1860s, all dams, mills and water rights were held by members of the Gardiner family and leased to individuals who ran the mills.

Gardiner was also a market for the western agricultural towns. In 1850, Gardiner was incorporated as a city and was one of the most important river ports on the Kennebec River. With the opening of the Kennebec and Portland Railroad Company in the 1850s, river traffic and trade drastically decreased, and Gardiner lost its importance as a river port. However, the railroad stimulated the town's industrial base by making the markets for Gardiner's products, Boston, Portland and New York, readily accessible.

By 1880 there were six large stone dams across the Cobbosseecontee that provided power for 21 industries. Many of these industries were sawmills, producing lumber products from logs sent downstream on the Kennebec from Moosehead Lake. By 1891 Gardiner's output of lumber was 11,000,000 feet per year as well as 6,000,000 shingles and 4,000,000 laths.

There were also several clapboard mills, a broom handle factory, a furniture manufacturer and wool and cotton mills. A large shoe manufacturing industry also developed in Gardiner, in the early 20th century.

The Gardiner Historic District is comprised of 47 primarily commercial buildings dating mostly from the 19th century. The district lies along both sides of Water Street with structures on one side of the street lying next to the Cobbosseecontee Stream. The commercial area developed as the town grew to become a major river port and industrial city, and still maintains its 19th century character. The historic district is listed on the National Register of Historic Places.

Skowhegan

The first permanent settlers arrived in Skowhegan in 1771. The town was part of the Kennebec Purchase and originally included land which is now the towns of Norridgewock and Milburn. Skowhegan was first called Canaan and was incorporated on 18 June 1788. In 1836, the name Canaan was changed to Skowhegan, the Indian name for the waterfalls on the Kennebec which were located within the town.

In 1785 a ferry service was licensed to connect the two areas of settlement in Skowhegan on the north and south banks of the Kennebec River. By 1793 three ferries, at

different landings, were in service. "The Proprietors of Skowhegan Bridge" was incorporated in 1805. The bridge was built from the north bank of the river to Skowhegan Island, and to the south bank from the Island.

The first saw and gristmill in Skowhegan was situated on Skowhegan Island, and began operation in 1790 on the Kennebec River. On Currier Brook, a potash mill was built in 1811 and at the same time an iron foundry was set up on the brook. The iron ore was extracted from the Thousand-acre Bog and was used for casting iron kettles and other implements. The foundry became a thriving business and in 1864 the company moved to Skowhegan Island. In the 1880s and 90s the Island Foundry became a major industry.

In 1811 a dam was erected across the south channel of the Kennebec River to power the industries at Mill Street. This area became the industrial center in Skowhegan during the 19th century.

Lumber operations were the main industry in the 1800s. By 1841 there were four sawmills, two shingle mills, a clapboard mill and two lath machines on the south channel. In the 1850s a planing mill was started as well as a sash and blind factory. From 1882 to 1926 the Novelty Works produced lawn chairs and wooden household goods. Other industries of importance during the 19th century were several tanneries, foundries, oil cloth factories and paper and pulp mills.

The Somerset and Kennebec Railroad was opened from Augusta to Skowhegan in 1856. This branch line was taken over by the Portland and Kennebec railroad in 1864 and leased to the Maine Central in 1870. The railroad was a boon to the industrial development of Skowhegan by providing an easily accessible network to Boston, Portland and other markets.

The Skowhegan and Norridgewock Electric Street Railway was organized in 1894. To increase ridership, a summer resort was developed at the end of the route in Norridgewock and was known as "The Pines". The resort included a camp, dining hall, dance pavilion and bandstand. A similar resort named the Lakewood was set up by a rival trolley company, the Somerset Traction Co. in 1895. With increasing competition from automobiles, trolley service between Skowhegan and Norridgewock was discontinued in 1928.

Skowhegan's woolen and shoe industries developed in the 19th century and are still the town's major industries. The Skowhegan Woolen Manufacturing Company was built in the Mill Street area in 1874. This became the American Woolen Company in 1899. In 1916, additional properties were purchased and the productive capacity of the mill was doubled. It was renamed the Anderson Mills. During World War I, the mills produced uniforms for the Army. In 1932 the mills began manufacturing fabrics for women's sportswear, and is now the largest manufacturer of this type of material. In 1940 the Anderson Mills employed almost 750 individuals.

In 1882, Mr. W.G.S. Keene came to Skowhegan from Lynn, Massachusetts to organize interest in a shoe factory. This led to the construction of Keene Bros. shoe factory. In 1893, the Bloomfield Shoe Company was organized and occupied the Keene Bros. factory. The Somerset Shoe Company opened in 1916 and by 1939 employed 200 people. The Skowhegan

Moccasin Company began production in 1939.

Hydroelectric power development in Skowhegan began with the organization of the Central Maine Power Co. in 1908. Construction of the dam and power station began 1 October 1919 on the south channel by Skowhegan Island. The power station was in operation by 1920. In 1921 the north channel dam was completed. The Skowhegan plant was the largest development of the Central Maine system at the time of its completion.

Pittsfield

Pittsfield was first known as Plymouth Gore, an early land grant under the Virginia Charter of 1606. This territory later came under the control of the Kennebec Proprietors. The first permanent settler, Moses Martin, arrived in 1790. There were no other settlers until 1804. Between 1806 - 1820, the population of Plymouth Gore increased fairly rapidly, and by 1820 there were 40 to 50 families living in the area.

In 1816, the settlement became the Seabasticook Plantation, and in 1819 the area was incorporated as the town of Warsaw. The name of the town was changed to Pittsfield in 1824, in honor of William Pitts, Esq., a local landholder.

Between 1830 and 1860 the growth of the town was steady, but slow. In 1860, the only business enterprises in Pittsfield were the saw and grist mills, three or four blacksmith shops, a carriage shop and several stores. The Boston Manufacturing Company introduced a tannery in 1838, but the business failed after two years.

In 1854 the Penobscot and Kennebec Railroad Company completed the line between Waterville and Pittsfield. The railroad helped to stimulate the town's economy. In 1867 a granite dam was constructed across the Seabasticook River and the Pioneer Woolen Mill was built. By the late 1800s the Pioneer mill was known as the Robert Dobson Company, and employed 300 people.

Pittsfield began manufacturing clothing in 1871. By 1880 there were ten pants manufacturers, as well as a manufactory of ladies wear. Other industries included a brickyard, harness shop, the Pioneer mill and a second woolen mill, the Seabasticook. In 1891 the Douglas Dam was built on the Seabasticook River. The Bryant and Woodruff woodworking plant was located on the new dam. The Waverley Woolen Mill opened in 1892.

During the 1880s the Seabasticook and Moosehead Railroad Company was incorporated. The road followed the West Branch of the Seabasticook River from Pittsfield to Moosehead.

The Pittsfield Electric Light and Power Company was incorporated in 1900. The company was acquired by the Seabasticook Power Company in 1903, which built the Burnham Dam to furnish electricity. The Central Maine Power Company took over operations in 1914.

In 1914 Pittsfield's three woolen mills were sold to the American Woolen Company. In 1934, American Woolen closed down the Waverley and Seabasticook mills. The

Pioneer mill remained open until 1953. The Northeast Shoe Company began operation in the Waverley mill in 1948. In 1966, with almost 700 employees, they were the largest single employer in Pittsfield. The Edwards Company purchased the Pioneer property in 1953 and constructed a new plant which opened in the late 1950s.

Pittsfield currently has several diverse industries. These include the Northeast Shoe Company, the Maine Fence Co., Pittsfield Woolen Yarns Inc. and the Riverside Mill, a wool processing and spinning mill.

Farmington

The Association of the Proprietors of Sandy River Township was formed in 1777. The first families moved into what became known as Farmington sometime after this date. In 1782 the population was around 39. The town's first grist mill was built that year. By 1787 settlement increased rapidly and the first school was established in 1788. Farmington had become a small farm community with a population of 494 in 1790 and 942 by 1800.

At Farmington Falls, a fulling mill and saw and grist mill were in operation by 1800. Other saw and grist mills were built at around the same time on Temple Stream and Fairbanks Stream. A dam was built on Fairbanks Stream in 1810 to power a fulling and carding mill. These were abandoned in 1840. Other early industries included several tanneries, a hat manufactory, clover mill, pottery and carriage shop.

The Franklin and Kennebec Railroad Company was incorporated in 1847. A line between Augusta and Farmington was completed in 1859. In 1883, several proposals were considered for a narrow gauge railroad between Farmington and Kingfield. The Franklin and Megantic Railroad was organized in 1884 and the track was completed the same year.

The carriages made in Farmington were very popular throughout the 19th century, and by 1883 there were 18 carriage shops. These carriages were sold throughout the state of Maine. Other Farmington industries included several woodworking shops, three corn canning factories and a fishing rod manufacturer. In 1877, the Greenwood's Champion Ear-Protectors were manufactured at West Farmington. Most of these industries were small and the economy of Farmington in the 19th century was never based solely on manufacturing.

PROBLEM IDENTIFICATION

FLOOD HISTORY

There are historical references to floods on the Kennebec River dating back to January 1770 but there is little information on the relative magnitude of floods prior to 1892. It was in 1892 that the Hollingsworth and Whitney Company began to maintain records of flows in the river at their dam in Waterville. Comparative peak flow data for nine flood events at selected locations in the basin since 1892 are listed in Table 3. There are some inconsistencies in peak flow estimates for historic floods and many of the flood events included ice jams. The formation and break up of ice jams could affect resulting local peak discharges and, most particularly, flood levels. The floodflow history would indicate that the December 1901 event approximated the March 1936 flood at Waterville. However, it is known that flood levels on the lower main stem of the Kennebec were affected in 1936 by ice jams. Prior to the March/April 1987 event, the March 1936 event was the greatest known historic flood on the lower main stem Kennebec.

The most recent Kennebec flood was the result of high volume rainfall and accompanying snowmelt occurring on the last day of March and the first day of April 1987. This rainfall followed several days of daytime temperatures in the sixties. The resulting runoff produced new floods of record in the Kennebec basin generally from the mouth of the Carrabassett tributary downstream throughout the middle and lower basin. Peak flows on the lower main stem Kennebec and tributaries (Sandy, Carrabassett and Sebasticook Rivers) ranged from 20 to 30 percent greater than the previous record flood of March 1936.

Floods in the basin have occurred most frequently in the spring as a result of snowmelt alone or in combination with rainfall. However, two floods were experienced in December, both as a result of mostly intense rainfall. Also a more recent flood event, in May/June 1984, occurred as a result of intense rainfall. Though there was a great flood on the river in December 1901, hydrologic data for the event is sketchy and questionable due to difficulties in developing reliable rating curves. The major flood of 1936 was really the first event with reasonably sufficient flow data for analysis. Though the 1936 event was a major flood, Moosehead Lake storage controlled the flood runoff from its 1,268 square miles of watershed and outflow from the lake did not significantly contribute to downstream flood peaks. Similarly, in the lesser March 1953 flood, Flagstaff Lake, completed in 1950, in combination with Moosehead Lake, provided a high degree of control over flood flow contributions from their combined watershed areas of 1,788 square miles. In studies by the Corps in 1953 it was generally concluded, based on the flood history at that time, that floods on the Kennebec were produced largely by runoff from the watershed area below Flagstaff and Moosehead Lakes, with these two lakes effectively controlling, or at least desynchronizing, flows from their watersheds, which represent 30 percent of the total Kennebec River watershed.

It was further concluded that the mountainous Carrabassett and Sandy River tributaries were major contributors to flood peaks on the main stem Kennebec River. Since the flood of March 1953 and the Corps analysis at that time, there have been significant floods in the basin in December 1973, April 1979, April 1983, May/June 1984, and the recent major March/April 1987 event.

FLOOD PROFILES

Flood profiles of the main stem Kennebec River for the March 1936 flood were developed during past Corps studies. These profiles from Gardner to Madison are shown on Plates 6 to 12. The profiles were developed based on surveyed 1936 flood elevations. Also shown is an approximate low flow profile and the March/April 1987 flood elevations, as surveyed by the USGS. It is noted that while the profiles were originally developed in the 1950's, a cursory review of the major dams along the river with recent profiles presented in various flood insurance study reports, for the most part does not indicate any significant change in the crest elevations of the dams. These profiles are presented to provide an indication as to the relative magnitude of the 1987 flood event as compared to the previous record flood of March 1936. In addition to these flood profiles, Table 4, "Flood Elevations Kennebec River," lists surveyed March 1936, March/April 1987 and computed 100-year flood elevations as determined by the Federal Emergency Management Agency (FEMA). It is noted that the FEMA 100-year elevations were determined before the major March/April 1987 flood event, with analysis conducted generally in the mid 1980's.

ANALYSIS OF FLOODS

In 1985 the Corps completed a report titled, "Hydrology of Floods, Kennebec River, Maine, Part I". The study was conducted under the authority contained in Section 22 of the Water Resource Act of 1972. Contained in that report are analyses of four recent Kennebec River flood events, namely: December 1973, April 1979, April 1983, and May/June 1984.

Available streamflow data from the U.S. Geological Survey plus data provided by the Kennebec Water Power Company was used for the flood analysis. Flood inflow hydrographs to the three principal storages: Brassua, Moosehead and Flagstaff Lakes, were computed using reported average daily outflows and daily changes in lake storage data in the continuity equation:

$$\text{Inflow} = \text{Outflow} + \Delta \text{ Storage}$$

TABLE 3
KENNEBEC RIVER BASIN
FLOOD HISTORY (1892 - DATE)

Flood	Peak Discharges						
	Kennebec at Forks (1) (DA = 1,590)	Kennebec at Bingham (1) (DA = 2,715)	Kennebec at Skowhegan (2) (DA = 3,894)	Kennebec at Waterville (3) (DA = 4,270)	Kennebec at North Sidney (DA = 5,478)	Sandy River Nr Mercer (1) (DA = 514)	Carrabassett River Nr North Anson (1) (DA = 353)
Mar 1896	-	-	-	113,000 cfs	-	-	-
Dec 1901	22,400	-	-	115,000	-	-	-
Apr-May 1923	17,700	-	-	135,000	-	-	-
Mar 1936	15,200	58,000	113,000 (4)	154,000	-	38,600	38,000
Mar 1953	8,000	28,400	-	112,000	-	36,900	30,400
Dec 1973	24,900	50,300	110,000 (123,000) (5)	145,000 (6)	-	25,600	20,000
Apr 1979	77,200	41,000	101,000	105,000 (7)	111,000	24,900	22,400
Apr 1983	28,300	55,400	82,000	90,000 (7)	107,000	-	13,700
May-Jun 1984	31,500	65,200	76,000	102,000 (7)	113,000	-	13,000
Mar-Apr 1987	20,400	63,400	-	190,000 (7)	220,000	46,000	41,000

(1) USGS Gaging Station.

(2) Daily flow data by Kennebec Water Power Company and Central Maine Power Company.

(3) Data by Hollingworth and Whitney Company.

(4) From Corps file notes.

(5) Newspaper account of peak.

(6) From Regional Planning Committee Flooding Report dated February 1987.

(7) Estimated from Army Corps of Engineers study.

TABLE 4
FLOOD ELEVATIONS
KENNEBEC RIVER
(Feet NGVD)

<u>River Mile</u>	<u>Community</u>	<u>1936</u>	<u>1987*</u>	<u>FEMA** 100 Year</u>
36.8	Gardiner/Randolph	26.5	24.7	28.5
40.9	Hallowell	29.6	29.1	-
43.6	Augusta D/S Dam	30.9	37.0	38
43.7	Augusta U/S Dam	35.4	38.4	38
55.2	N. Sydney Gage	-	54.3	-
61.4	Waterville D/S Dam	57.3	-	60
61.5	Waterville U/S Dam	65.0	-	66
62.5	Waterville U/S Dam	68.9	-	79
62.6	Waterville U/S Dam	87.3	-	88
65.0	Fairfield	95.1	100.6	96
68.4	Shawmut D/S Dam	105.2	110.0	108
68.4	Shawmut U/S Dam	118.5	120.4	120
81.5	Skowhegan D/S Dam	150.0	150.2	-
81.5	Skowhegan U/S Dam	162.5	173.2	164
85.9	Norridgewock	171.8	-	170
92.9	Mouth Sandy River	186.9	192.8	183
95.0	Madison D/S Dam	187.7	-	170
95.1	Madison U/S Dam	228.6	-	-
95.4	Madison D/S Dam	239.6	253.6	-
95.5	Madison U/S Dam	255.1	258.2	-

*Data provided by USGS.

**Approximate 100-year flood elevation determined from FEMA flood profiles.

The resulting hydrographs at the storages, shown in the 1985 report, are approximate since

TABLE 5
KENNEBEC RIVER
COMPONENT CONTRIBUTIONS
TO FLOOD DISCHARGES

COMPONENT	DRAINAGE AREA (sq. mi.) (%)		PERCENT CONTRIBUTION TO PEAK FLOW						
			1953 Studies	1973 Flood	1979 Flood	1983 Flood	1984 Flood	1987 Flood	1973-1987 Avg Flood
BINGHAM GAGE									
Kennebec above the Forks	1,590	59	27	40	40	51	45	33	41
Dead River	874	32	35	32	35	26	40	30	33
Local	251	9	38	28	25	23	15	37	26
	2,751	100							
NORTH SIDNEY GAGE									
Kennebec above the Forks	1,590	29	7	14	12	22	24	10	16
Dead River	874	16	10	12	14	15	22	9	14
Local to Bingham	251	5	10	9	9	10	7	9	9
Carrabassett River	354	7	16	14	19	13	10	17	15
Sandy River	514	10	24	20	20	14	12	20	17
Sebasticook River	946	17	8	11	4	13	10	9	10
Local	874	16	25	20	22	13	15	26	19
	5,403	100							

they are based on average daily outflow and reservoir stage data. Hydrographs at USGS gaging station are based on hourly data. Component outflow hydrographs were progressively combined and routed downstream. The routed hydrographs were checked for timing with USGS gaging station flow records. Hydrographs were subtracted from the recorded hydrographs to determine residual runoff hydrographs attributable to the intervening local areas.

Based on the analysis, the finally adopted travel times for hydrograph routing was as follows.

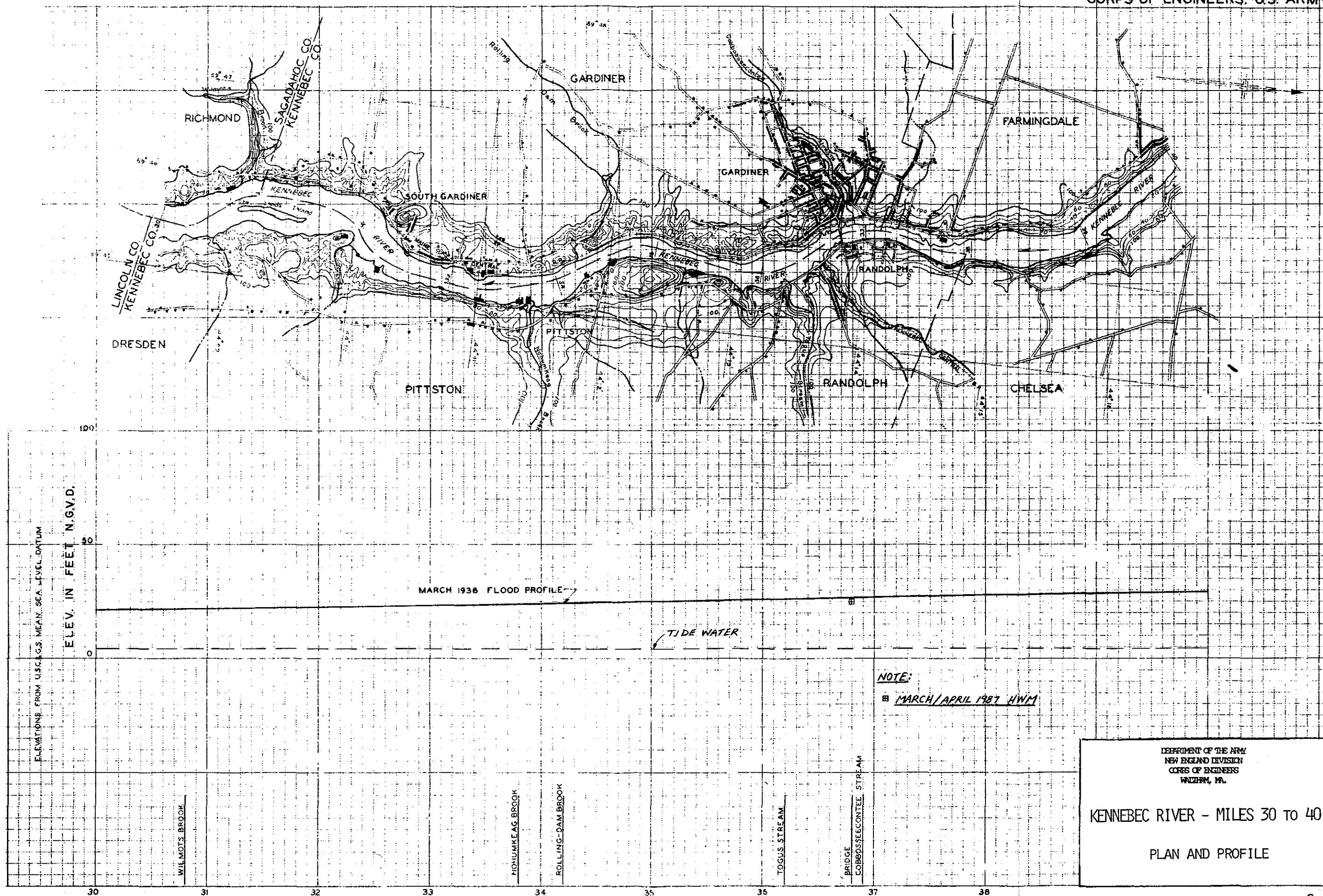
<u>Reach</u>	<u>Travel Time</u> (hours)
Lakes to Forks	4
Forks to Bingham	4
Bingham to Mouth Carrabassett	4
Carrabassett to Skowhegan	4
Skowhegan to Waterville	4
Waterville to North Sidney	4

Resulting component contributions to peak floodflows on the Kennebec River from the Forks to Augusta, are shown graphically on Plate 13 for the recent floods of 1973, 1979, 1983, and 1984. Component contributions in percent, at Bingham and North Sidney, are listed in Table 5. For comparison purposes, percent component contributions are listed by: (a) drainage area, (b) typical peak discharge contributions as estimated in 1953 studies by the Corps, and (c) estimated peak discharge contributions, for the recent floods analyzed.

The flood of March/April 1987 was analyzed in "Hydrology of Floods, Kennebec River Basin, Maine, Part II". The study was conducted under the authority contained in Section 22 of the Water Resource Act of 1972. In that report component contributions were determined using provisional USGS streamflow and rainfall records. It is noted the final USGS report on the March/April 1987 flood had not been received during preparation of this water resources investigation. This was a new flood of record generally throughout the mid to lower Kennebec basin and, with the upper basin reservoirs completely controlling the runoff from their contributing watersheds, dramatically demonstrated the flood producing potential of runoff from the uncontrolled downstream watersheds. Flood hydrographs and component contributions to peak flows, estimated and recorded, are shown graphically on Plate 14.

In analyzing the 1987 flood, the local contribution hydrograph between the Forks and Bingham gages was computed by lagging the Forks hydrograph 1 hour and subtracting from the Bingham data. Component contributions at North Sidney were computed by lag/averaging the Bingham hydrograph 16/7 hours and lagging the Carrabassett and Sandy River hydrographs 12 hours. Component contribution in percent at Bingham and North Sidney for the 1987 flood are also listed in table 9.

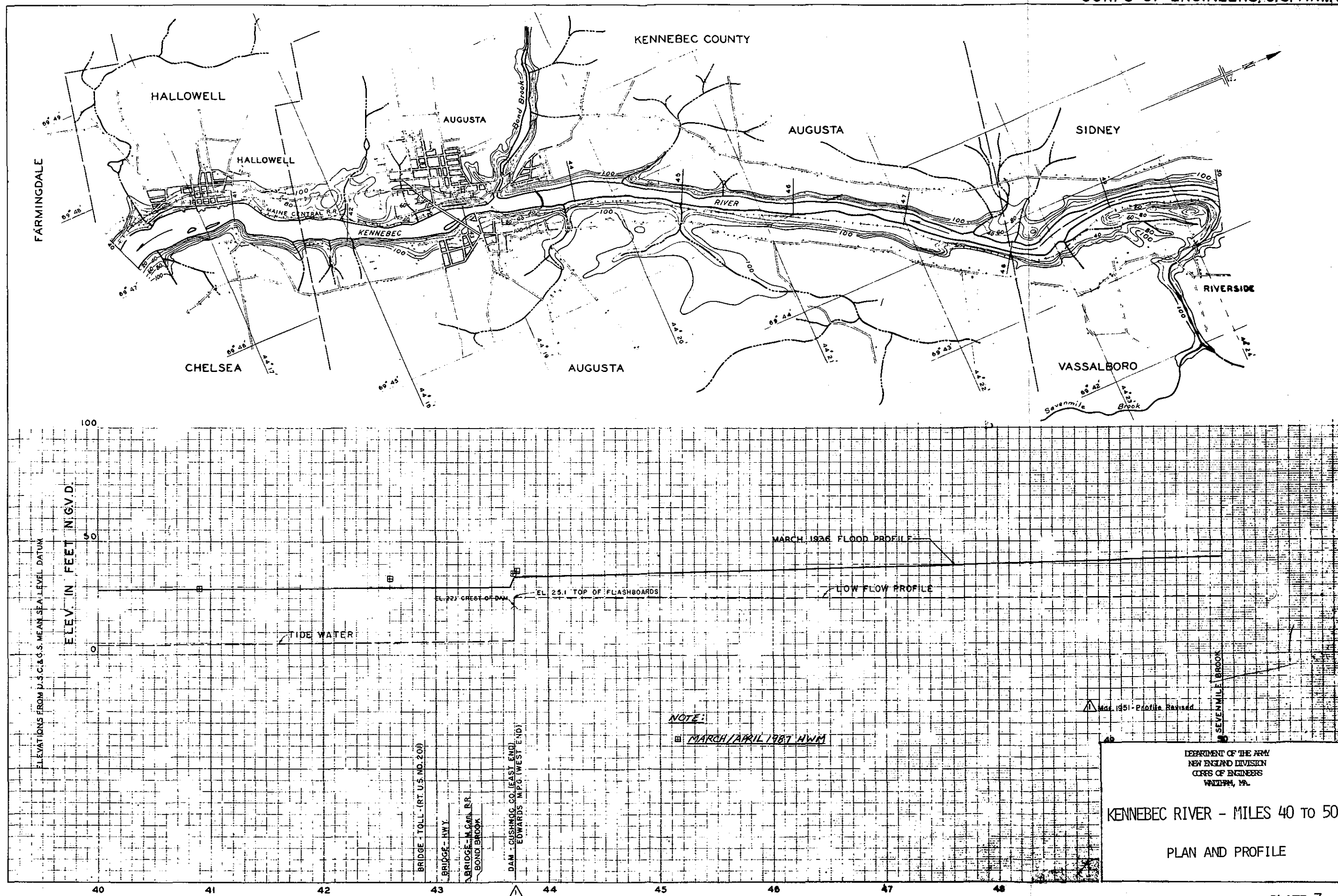
In 1953 studies it was concluded that upper basin floodflow contributions were typically modified and desynchronized by reservoir storage, as indicated by the then analyzed 1936 and 1953 flood events. However, in the five more recent floods, the contribution from the upper



DEPARTMENT OF THE ARMY
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 CORPS OF ENGINEERS
 WALTHAM, MA.

KENNEBEC RIVER - MILES 30 TO 40

PLAN AND PROFILE



KENNEBEC COUNTY

SIDNEY

WATERVILLE

SIDNEY

NORTH SIDNEY

RIVER

KENNEBEC

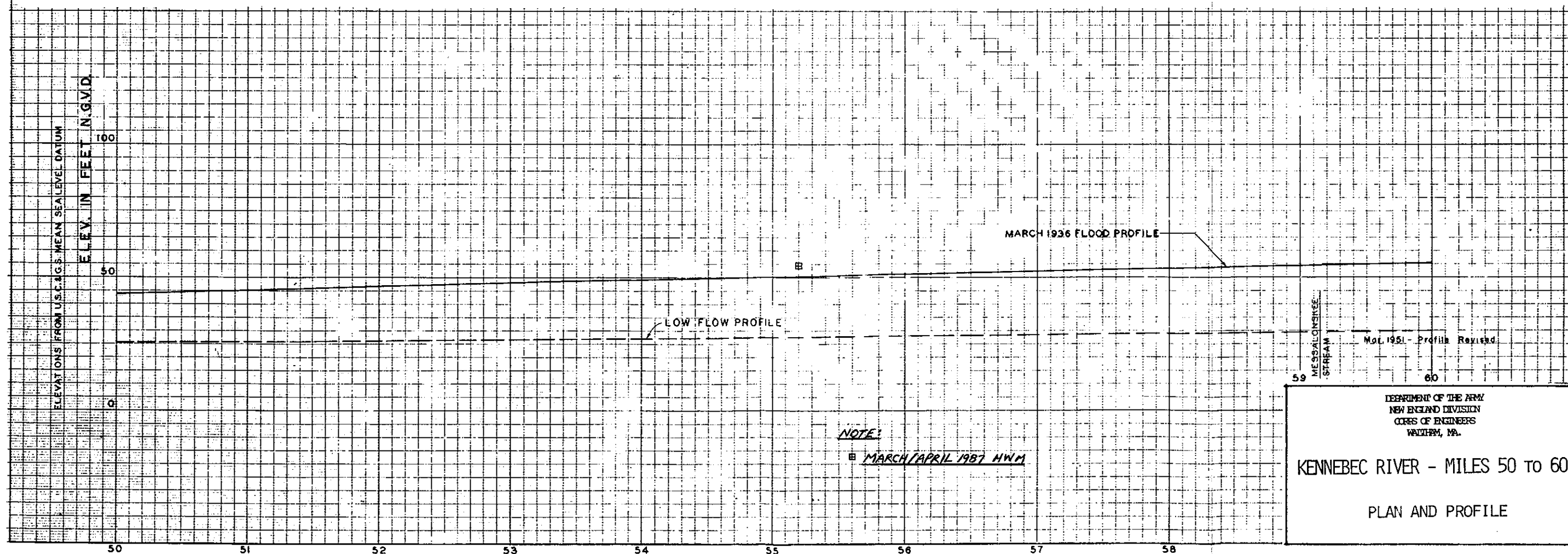
MAINE CENTRAL R.R.

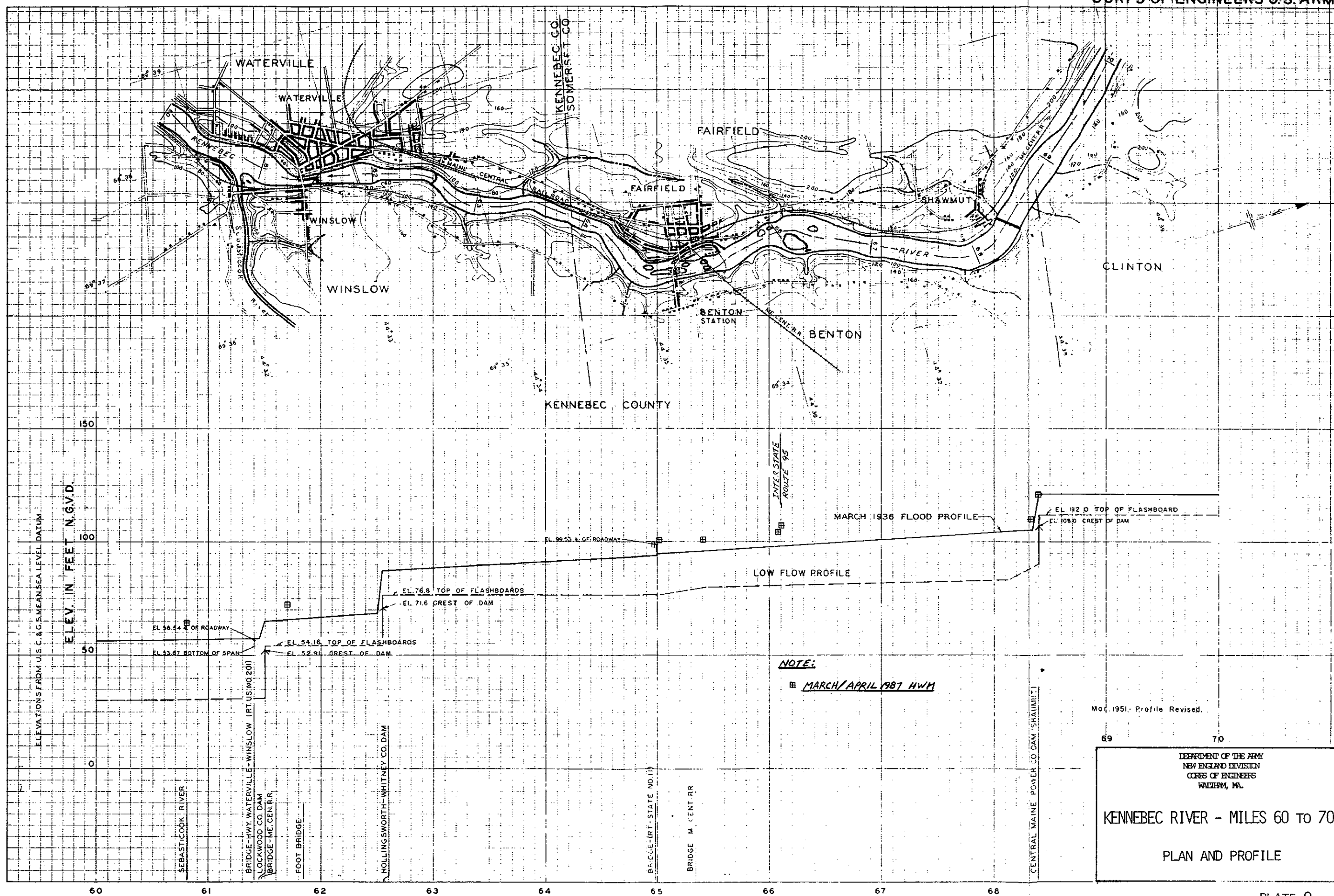
VASSALBORO

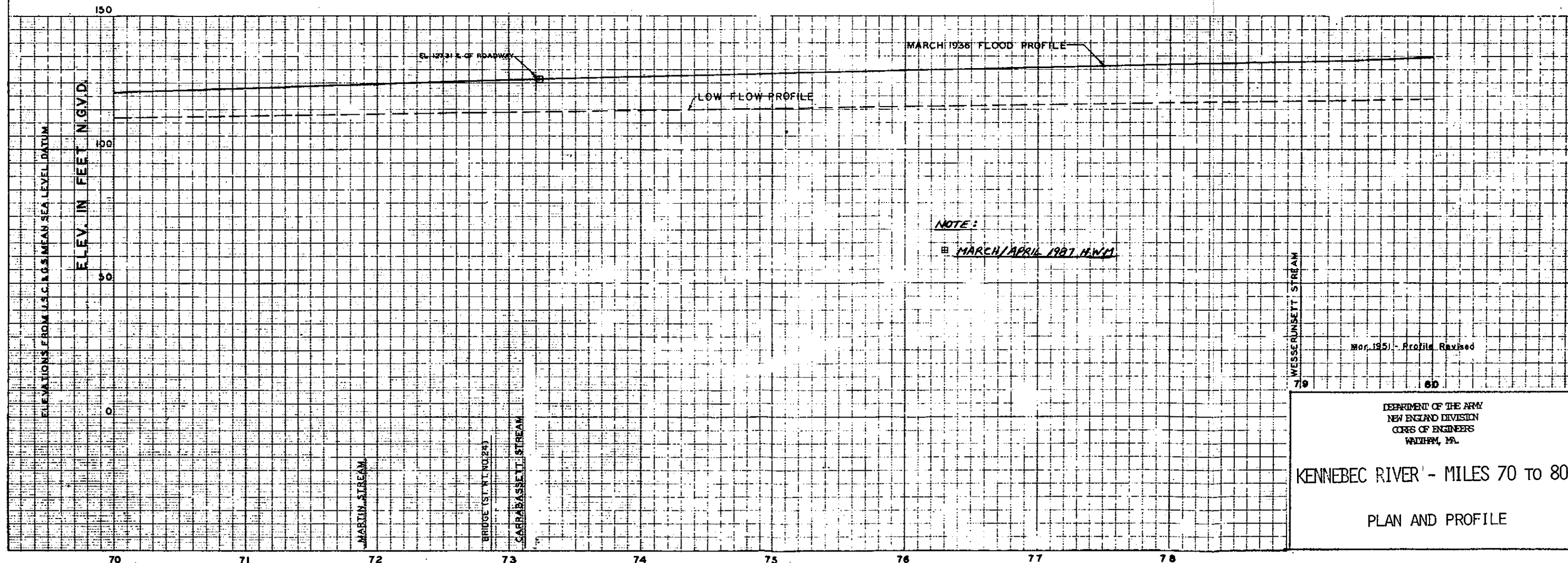
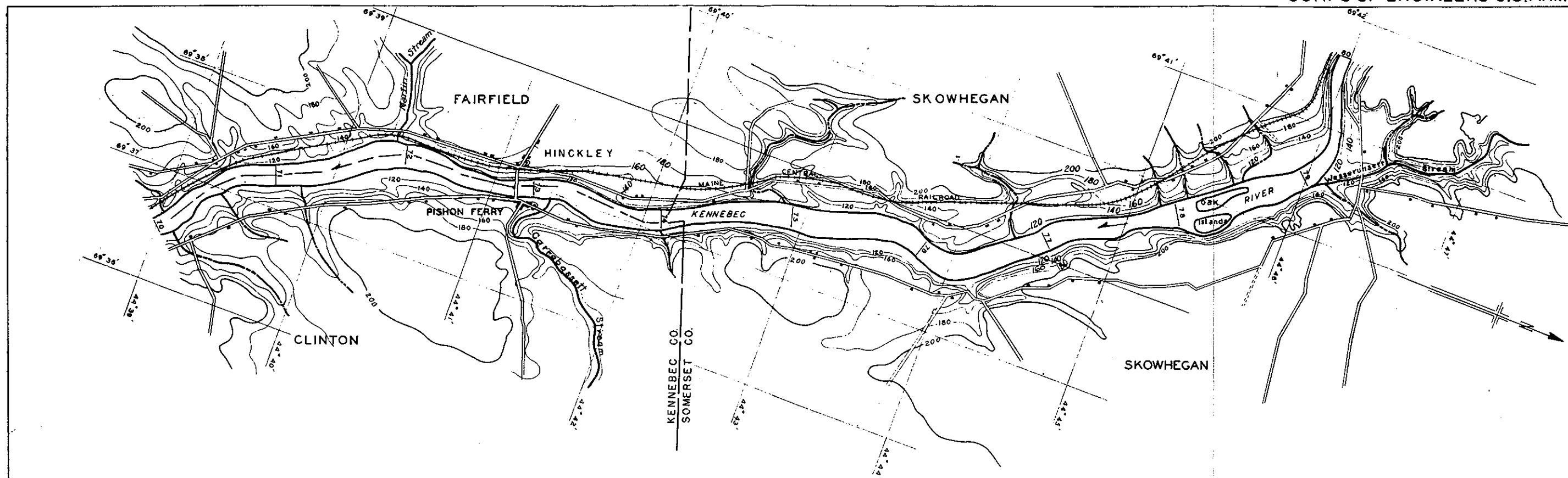
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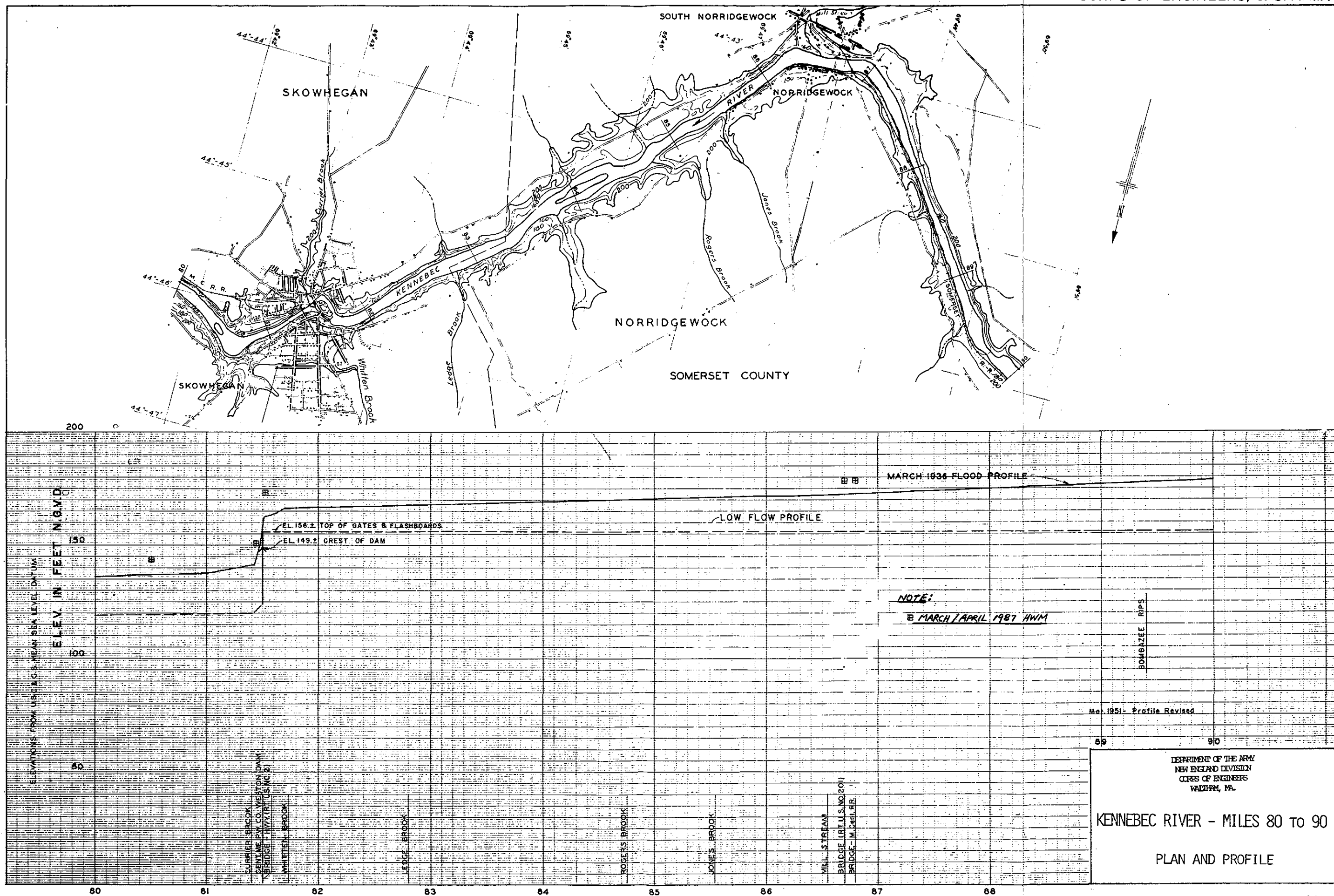
WINSLOW

Messalonskee Stream

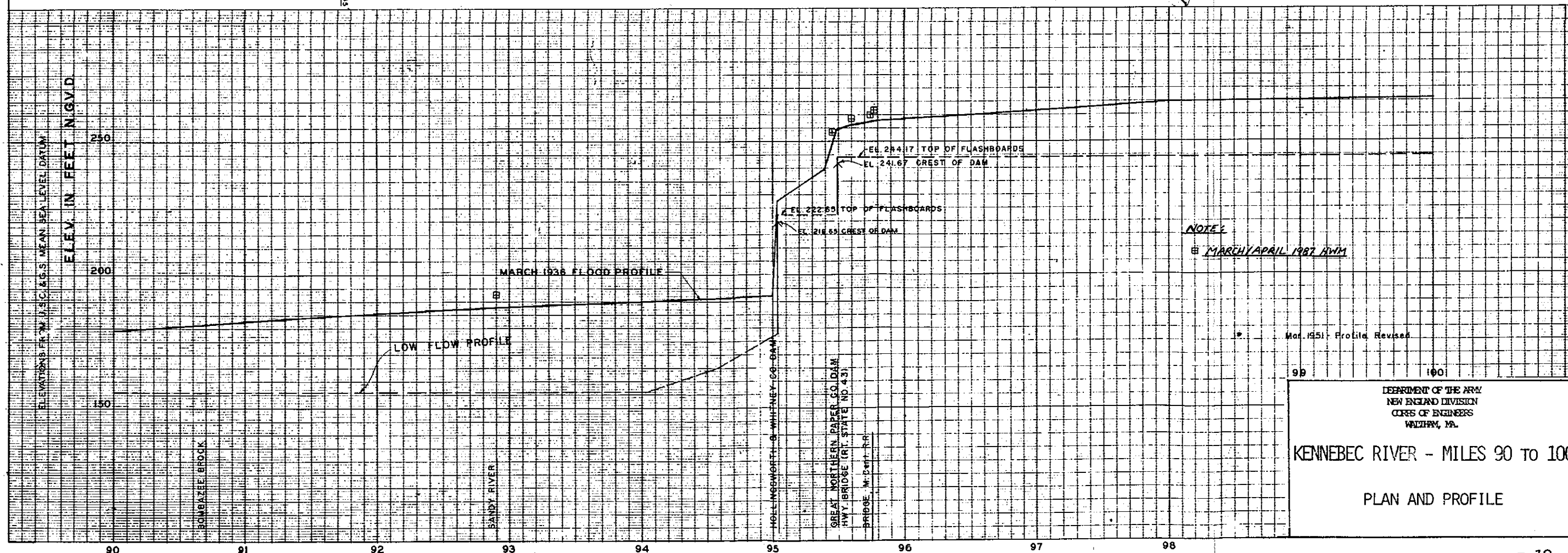
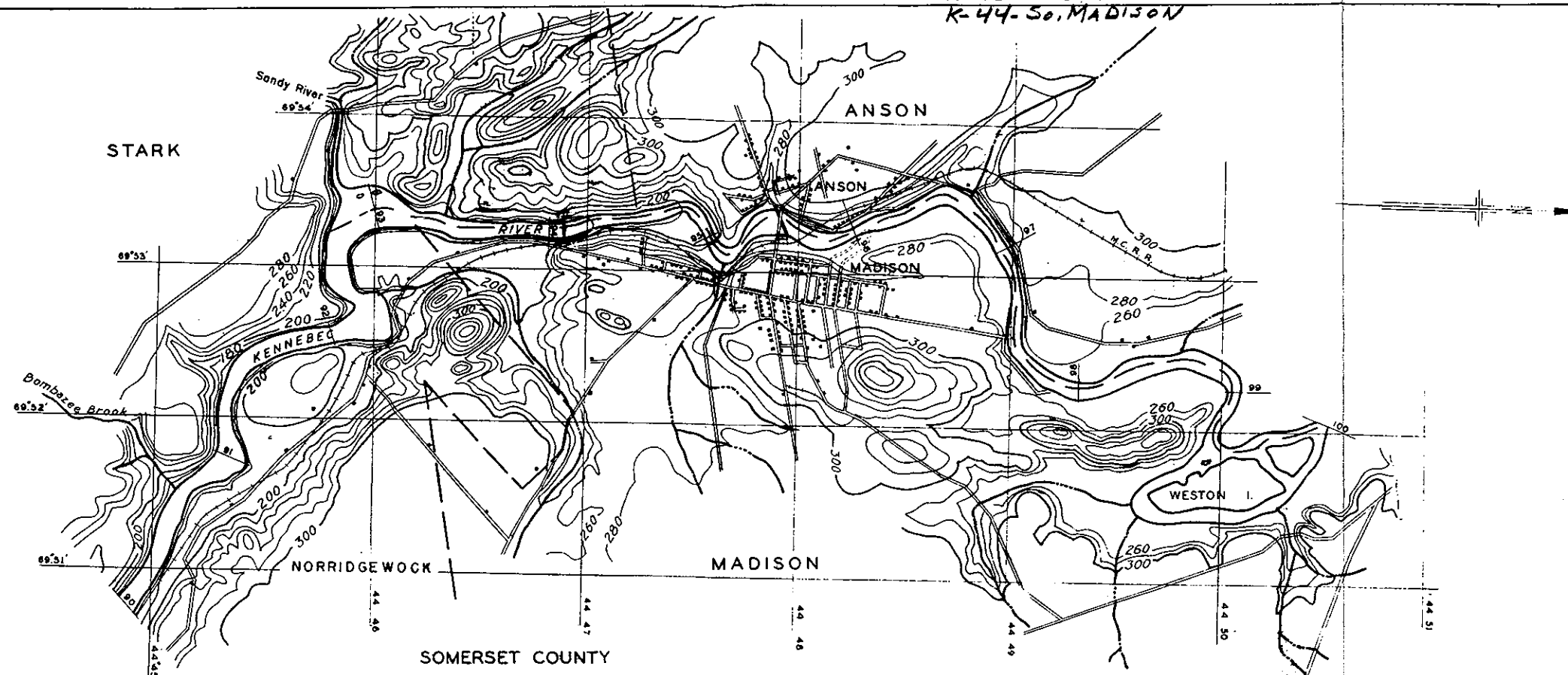


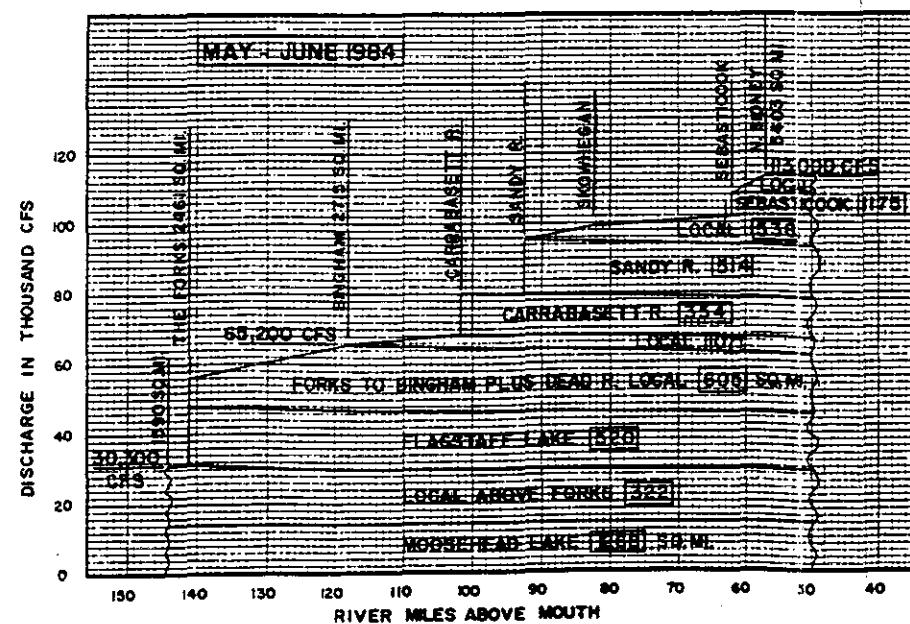
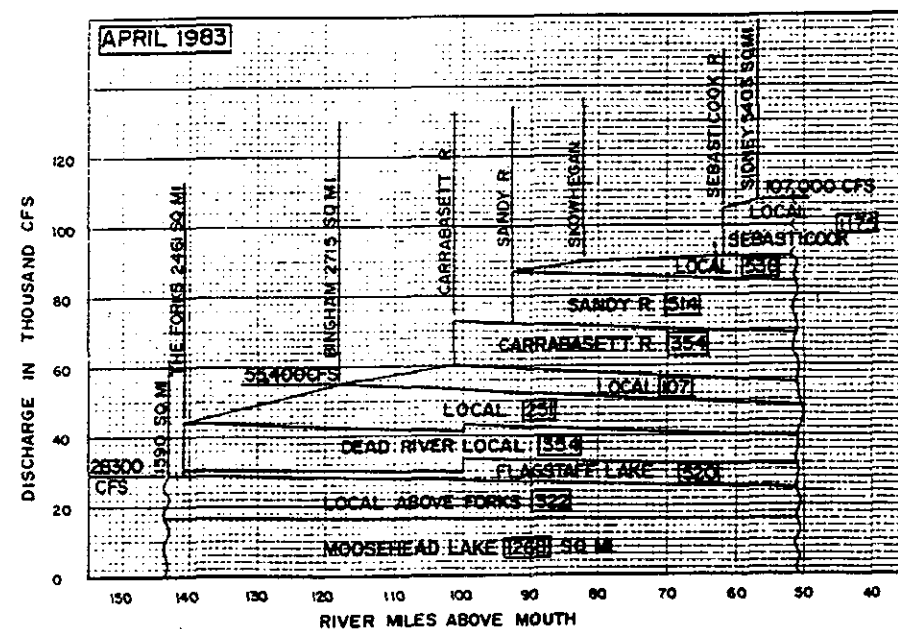
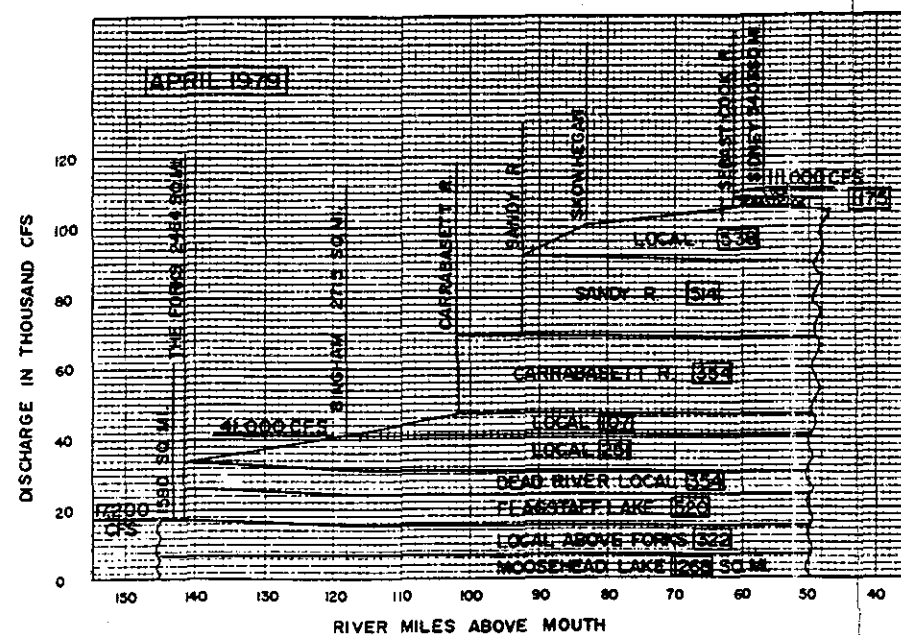
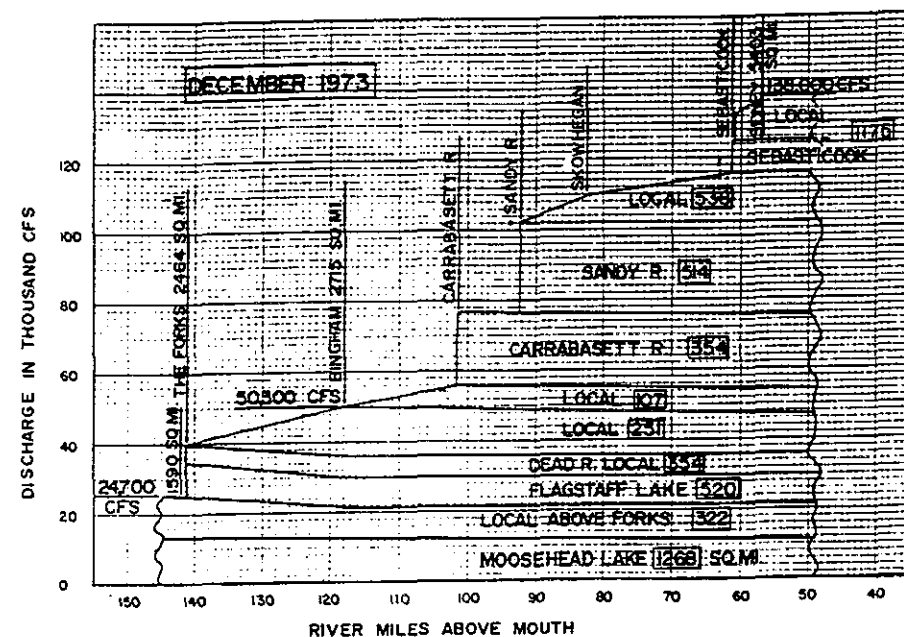






K-42-MADISON
K-43-ANSON
K-44-So. MADISON

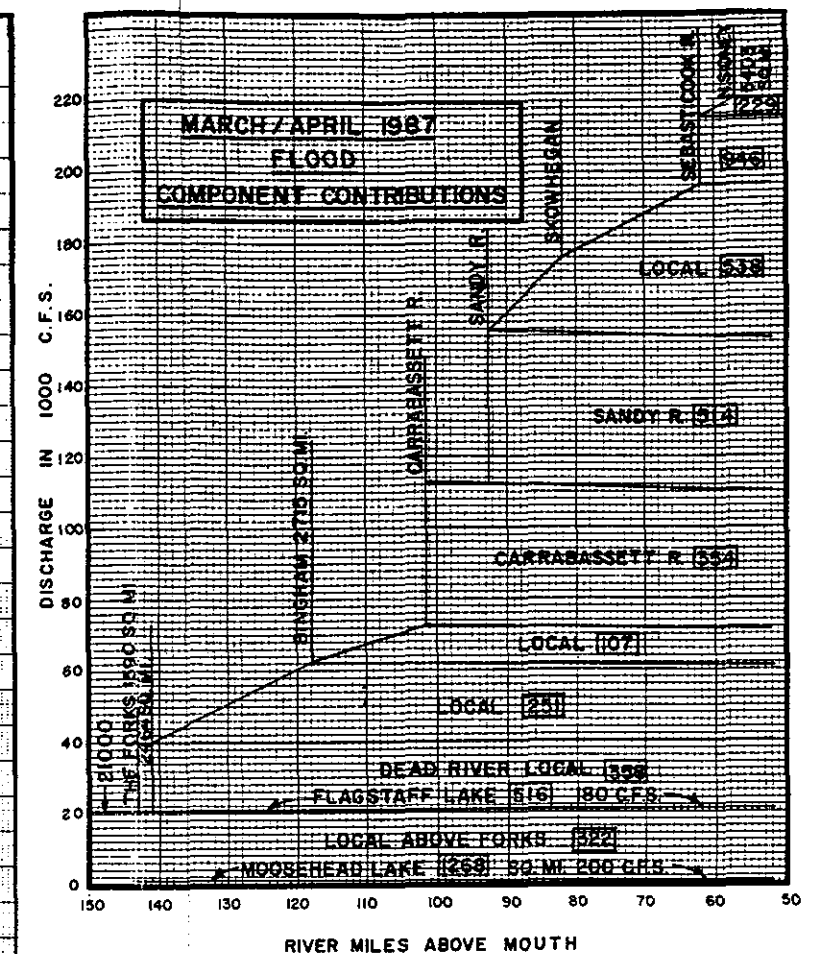
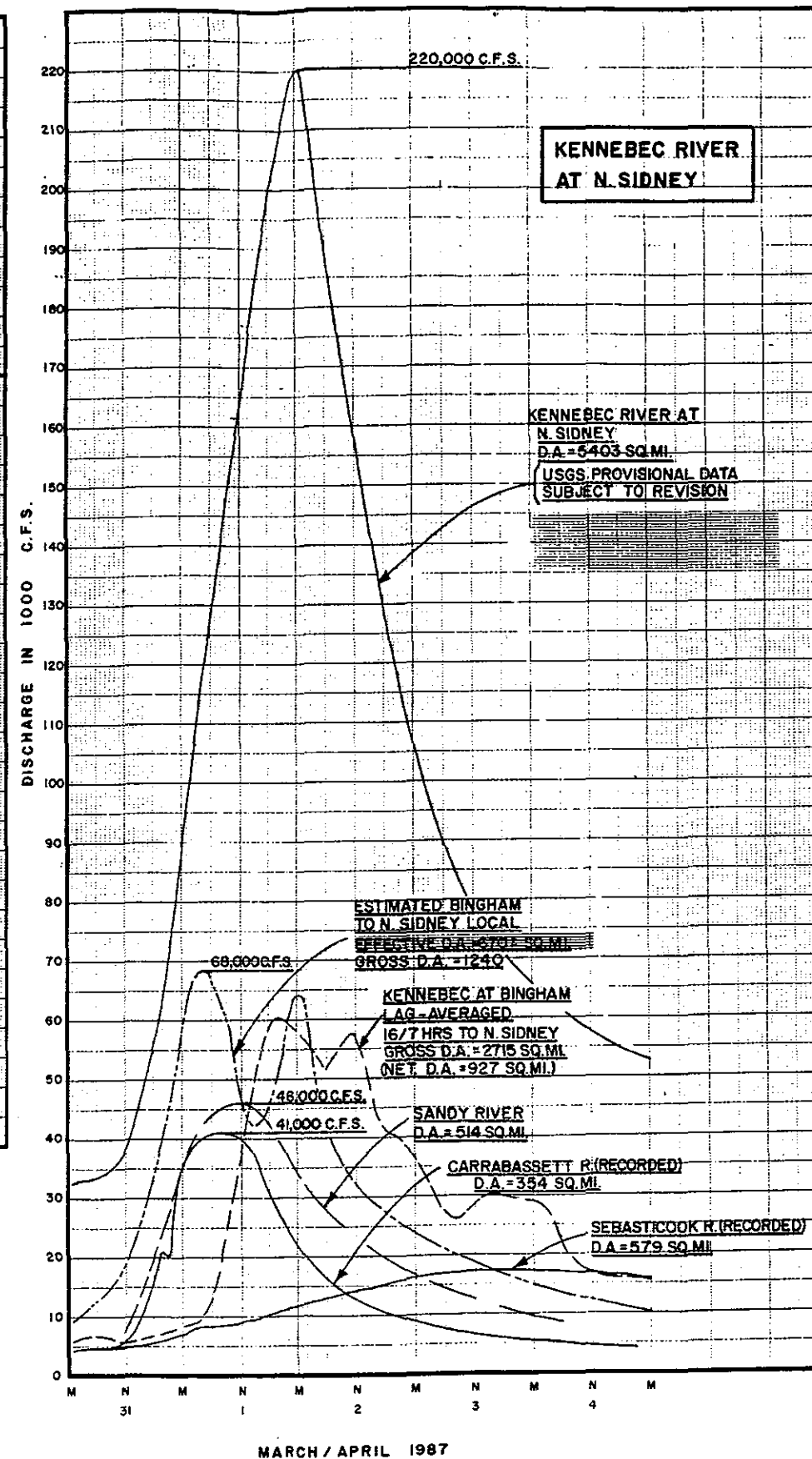
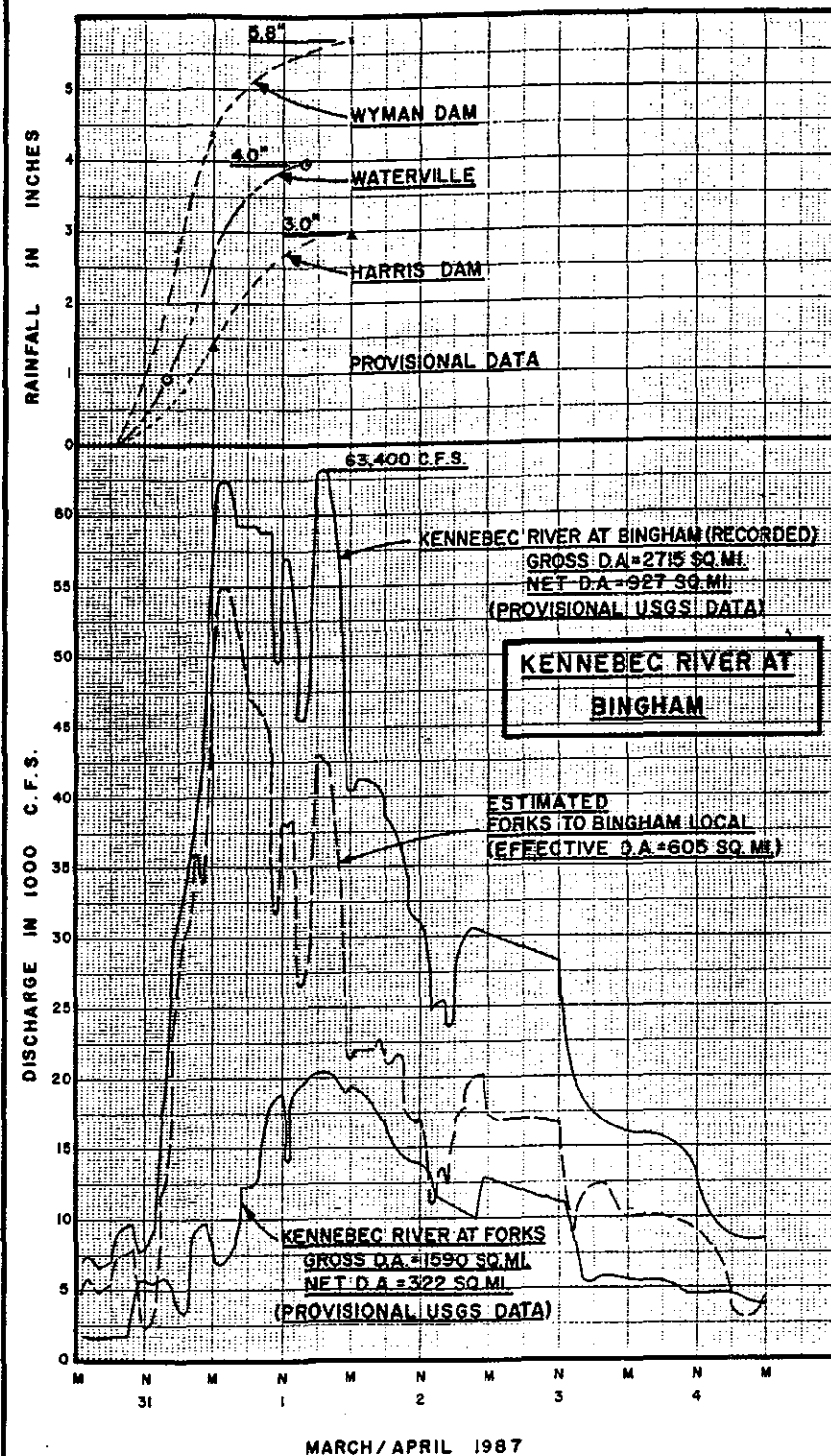




DEPARTMENT OF THE ARMY
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CORPS OF ENGINEERS
WALTHAM, MASS.

**KENNEBEC RIVER BASIN
FLOOD DISCHARGE PROFILES
AND
COMPONENT CONTRIBUTIONS**

KENNEBEC RIVER, MAINE



DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

KENNEBEC RIVER BASIN
FLOOD ANALYSIS
MARCH - APRIL 1987

basin was found to be more significant. The watershed area above Bingham represents 50 percent of the total area above North Sidney and its discharge contribution to the flow at North Sidney averaged about 39 percent during the five most recent floods (including March/April 1987), as compared to an estimated typical contribution of 27 percent in 1953. The uncontrolled mountainous Carrabassett and Sandy Rivers remain high flood flow contributors relative to size of drainage area.

FLOOD DAMAGES

The State provided information by community, estimating losses suffered during the 1987 flood event. The State also provided information on the estimated assistance payments for such items as: low interest loans to uninsured (or under insured) private property owners and outright grant money to hardship cases, as well as one-time cost of public services. The estimated losses for communities in the Kennebec basin from the 1987 event was estimated by the State at \$34 million. The estimated assistance payments for the basin were estimated at \$9.1 million.

Due to the large size of the basin and the number of communities involved, NED suggested and the State of Maine concurred, that the study area be limited in order to provide meaningful information within the short timeframe of the study. Communities with estimated losses of \$500K or more were selected for analysis. The screening process resulted in the selection of 14 communities. Total damages for the communities selected represented approximately 90 percent of the total damages reported by the State. The following communities were selected for analysis.

Augusta	Hallowell	Gardiner
Randolph	Waterville	Winslow
Fairfield	Skowhegan	Norridgewock
Anson	Madison	Pittsfield
Hartland	Farmington	

As the study progressed it was found that only 12 of the 14 communities selected warranted additional study. After a preliminary review, the towns of Norridgewock and Hartland were screened from further analysis. In Norridgewock only one structure was in the flood plain. In the town of Hartland the flood damages were attributed to the partial failure of a small dam on the Sebasticook River not overbank flooding. The dam has had remedial repairs and did not warrant further investigation.

Flood Damage Survey

A flood damage survey was performed in the 12 areas by an NED flood damage evaluator during July to September 1988. Flood related losses were estimated for each floodprone structure and site beginning at the elevation at which discernible losses and damages are first

incurred up to the flood elevation of a rare and infrequent (500-year) event. The reference point at each structure was the first floor elevation. In addition to the NED flood damage survey effort, a local architectural engineering firm was contracted with to perform a nonstructural investigation for the 12 communities. As part of this contract, ground and first floor elevations were obtained for all structures in the 100-year floodplain. These elevations provided an additional level of confidence in the estimates of annual losses and benefits. The NED damage evaluator conducted interviews with knowledgeable local people concerning flood losses to commercial, industrial and public activities. For residential properties, use of sampling, typical loss profiles by type of house and minimal interviewing were employed. Both physical and non-physical losses were estimated. The cost of emergency services were obtained where possible. Damages to transportation, communication and utility systems were also obtained from the towns, the State of Maine Dept. of Transportation and the Central Maine Power Co.

Recurring and Annual Losses

Recurring losses are those potential flood related losses which are expected to occur at various stages of flooding under present day development conditions. As the final output of the flood damage survey process, recurring losses are estimated as an array of dollar losses, in one foot increments, from the start of the damage to the elevation of a rare and infrequent (500-year) event.

The purpose of estimating annual losses is to measure the severity of potential flooding on an "expected annual" basis in each damage center. Annual losses are the integration and summation of two sets of data at each damage location. Recurring losses for each flood elevation (event) are multiplied by the annual percent chance of occurrence that each specific flood elevation (event) will be reached.

The effectiveness of each alternative flood reduction plan is measured by the extent to which it reduces average annual losses. Recurring and annual losses for the damage centers in each town are discussed as follows.

ANSON

In Anson, a total of 12 buildings, 6 commercial and 6 residential, along Main St. were identified as floodprone. However, they will not experience significant damages until the occurrence of events approaching the 100 year storm.

Recurring Losses - By Event

	<u>10 Year</u>	<u>50 Year</u>	<u>100 Year</u>	<u>500 Year</u>	<u>Annual Losses</u>
Anson	0	\$30,500	\$122,300	\$574,300	\$5,000

AUGUSTA

The main damage center in Augusta is the downtown commercial area along Water St. From the recurring loss table it can be seen that significant flood losses to this mixed area of commercial and residential activities begin at the 50 year flood event. In total, 40 structures are affected.

Recurring Losses-By Event

	<u>10 Year</u>	<u>50 Year</u>	<u>100 Year</u>	<u>500 Year</u>	<u>Annual Losses</u>
Augusta	\$93,000	\$1,828,100	\$3,381,900	\$5,710,900	\$209,400

FAIRFIELD

There are two separate damage centers in Fairfield. Located in the Water St. area is a sewage treatment plant, a church and 25 houses. In the Upper Main St. area are 17 residential structures, 4 commercial and a trailer park containing 47 mobile homes. Recurring losses are nearly equal for the two separate areas and become significant at events approaching the 100 year event.

Recurring Losses - By Event

	<u>10 Year</u>	<u>50 Year</u>	<u>100 Year</u>	<u>500 Year</u>	<u>Annual Losses</u>
Water St.	0	\$252,000	\$ 827,500	\$1,468,900	\$22,100
Upper Main St.	\$1,400	193,800	716,000	2,834,100	32,900
Total Fairfield	1,400	445,800	1,543,500	4,303,000	55,000

FARMINGTON

A total of 32 structures were identified as having flood loss potential in Farmington. Located along Water St. and Lower Main St., the structures are nearly evenly divided among residential (15) and commercial (16) with one public building. Twenty-eight of the 32 structures have first floor elevations below the 100 year flood elevation which results in considerable recurring losses at the more frequent flooding events.

Recurring Losses - By Event

	<u>10 Year</u>	<u>50 Year</u>	<u>100 Year</u>	<u>500 Year</u>	<u>Annual Losses</u>
Farmington	\$ 281,300	\$1,373,300	\$1,833,700	\$1,975,000	\$125,400

GARDINER

There are 56 commercial structures in Gardiner that have a strong potential to experience flood losses. This is because the majority of the buildings have first floors at an elevation 5 to 8 feet below the 100 year flood elevation. Cobbosseecontee Stream flows through this area before joining the Kennebec and contributes to flood damage by backing up and rising when the Kennebec is at high stages. This stream also divides the 56 building damage center into 2 distinct parts. One part, the Main St. area, contains 47 structures while the other, the Shop 'N Save mall area contains 9. As expected, recurring losses are high for Gardiner.

Recurring Losses - By Event

	<u>10 Year</u>	<u>50 Year</u>	<u>100 Year</u>	<u>500 Year</u>	<u>Annual Losses</u>
Gardiner	\$1,237,000	\$5,191,800	\$5,579,500	\$5,851,000	\$425,000

HALLOWELL

Flood losses in Hallowell are concentrated in 30 commercial (retail) structures along both sides of Water St. The majority of these establishments are antique shops, book stores or restaurants. Most of the buildings have first floors at elevations 4 to 8 feet below the 100 year flood elevations. Recurring losses therefore become substantial at events approaching the 50 year flood.

Recurring Losses - By Event

	<u>10 Year</u>	<u>50 Year</u>	<u>100 Year</u>	<u>500 Year</u>	<u>Annual Losses</u>
Hallowell	\$126,000	\$1,973,000	\$2,284,500	\$2,432,000	\$117,100

MADISON

Located directly across the Kennebec from Anson, the town of Madison has one floodprone area. Of the 5 buildings in this area, only one, a restaurant is not a large factory type of building. All of the buildings have first floors below the 100 year event, however the area currently has a private system of dikes and walls which provides 50 year protection with no freeboard allowance. Flood losses are concentrated in the Madison Paper Industries buildings.

Recurring Losses - By Event

	<u>10 Year</u>	<u>50 Year</u>	<u>100 Year</u>	<u>500 Year</u>	<u>Annual Losses</u>
Madison	0	0	\$3,026,000	\$3,035,000	\$93,400

PITTSFIELD

The town of Pittsfield is located on the Sebasticook River and has a damage center which consists of 31 residential structures, 2 mobile homes, 1 commercial building and 1 public building. The majority of the houses have first floor elevations at or up to 2 feet below the 100 year flood event. Openings below the first floor range from 3 to 5 feet below the 100 year flood elevation. Significant flooding occurs at the more frequent flood events as there is only a 2 foot difference between the 10 year and 100 year flood level in the Pittsfield floodplain.

Recurring Losses - By Event

	<u>10 Year</u>	<u>50 Year</u>	<u>100 year</u>	<u>500 Year</u>	<u>Annual Losses</u>
Pittsfield	\$155,800	\$272,200	\$317,700	\$347,700	\$95,900

RANDOLPH

Randolph, located directly across the Kennebec River from Gardiner, Me., has a damage center comprised of 24 structures, the majority of which are residential. Only 3 buildings have first floor elevations at the 100 year flood level. The remainder vary from 3 to 10 feet below. Recurring losses therefore become significant at the more frequent flooding events.

Recurring Losses - By Event

	<u>10 Year</u>	<u>50 Year</u>	<u>100 Year</u>	<u>500 Year</u>	<u>Annual Losses</u>
Randolph	\$277,600	\$918,900	\$1,074,000	\$1,222,100	\$110,800

SKOWHEGAN

The damage center in Skowhegan consists of 18 residential structures, 4 commercial, 4 industrial and 2 public buildings. Roughly one-half of the structures have first floor elevations above the 100 year flood level, while the remainder average 1 to 3 feet below. Damages are not significant at the more frequent events. Even at the 50 and 100 year events, two-thirds of the losses are concentrated in two industrial concerns and a hydroelectric plan.

Recurring Losses - By Event

	<u>10 Year</u>	<u>50 Year</u>	<u>100 Year</u>	<u>500 Year</u>	<u>Annual Losses</u>
Skowhegan	0	\$417,000	\$3,212,000	\$5,557,800	\$69,400

WATERVILLE

The damage center in Waterville consists of 23 structures. Three properties account for the majority of the flood losses. These are the Hathaway Factory, the Central Maine Power Facility and the Sewage Treatment Plant. At the 50, 100 and 500 year event 3 activities account for 90, 90 and 85 percent respectively of recurring losses. The remaining number of properties is evenly divided between residences and commercial (retail) structures. One-half of the first floors of these buildings are at the 100 year flood level and the remainder range from 1 to 4 feet below.

Recurring Losses - By Event

	<u>10 Year</u>	<u>50 Year</u>	<u>100 Year</u>	<u>500 Year</u>	<u>Annual Losses</u>
Waterville	0	\$1,032,000	\$2,235,000	\$4,547,500	\$80,100

WINSLOW

Of the 21 structures in the Winslow damage center, 4 are houses, 2 are public buildings and the remainder are commercial. All of the buildings have first floor elevations below the 100 year flood level, with many from 5 to 10 feet below. Losses become significant at the more frequent flooding events.

Recurring Losses - By Event

	<u>10 Year</u>	<u>50 Year</u>	<u>100 Year</u>	<u>500 Year</u>	<u>Annual Losses</u>
Winslow	\$91,500	\$1,935,700	\$2,840,700	\$2,845,400	\$118,300

Recurring losses for selected events in the damage centers of the communities under investigation are summarized in Table 6. A summary of the annual losses are shown in Table 7.

Table 6
Recurring Losses-By Event

<u>Location</u>	<u>10 Year</u>	<u>50 Year</u>	<u>100 Year</u>	<u>500 Year</u>
Anson	\$ 0	\$ 30,500	\$ 122,300	\$ 574,500
Augusta	93,000	1,828,100	3,381,900	5,710,900
Fairfield	1,400	445,800	1,543,500	4,303,000
Farmington	281,300	1,373,300	1,833,700	1,975,000
Gardiner	1,237,000	5,191,800	5,579,500	5,851,000
Hallowell	126,000	1,973,000	2,284,500	2,432,000
Madison	0	0	3,026,000	3,035,000
Pittsfield	155,800	272,200	317,100	347,700
Randolph	277,600	918,900	1,074,000	1,222,100
Skowhegan	0	417,000	3,212,000	5,557,800
Waterville	0	1,032,000	2,235,000	4,547,500
Winslow	91,500	1,935,700	2,840,400	2,845,400
TOTAL	\$2,263,600	\$15,418,300	\$27,449,900	\$38,401,900

Table 7
Annual Losses

<u>Location</u>	<u>Annual Losses</u>
Anson	\$ 5,000
Augusta	209,400
Fairfield	55,000
Farmington	125,400
Gardiner	425,000
Hallowell	117,100
Madison	93,400
Pittsfield	95,900
Randolph	110,800
Skowhegan	69,400
Waterville	80,100
Winslow	118,300
TOTAL	<u>\$1,504,800</u>

FUTURE CONDITIONS WITHOUT FEDERAL PARTICIPATION

Without Federal participation the average annual flood losses for the twelve communities studied has been estimated at \$1.5 million. Average annual flood losses for the entire Kennebec River Basin will exceed this amount, and if development in the flood plain continues the average annual losses will increase.

The Kennebec River Basin is not presently heavily developed and large areas of the flood plain remain uninhabited. Preservation of the basins natural storage capacities in the headwaters of the main stem and in most of its tributaries has played a major role in reducing flood stages. Pressure to develop the flood plain areas will decrease this natural storage capacity of the basin, thus, increasing future flood stages in the basin. Commercial and residential structures that currently experience flood damages will not only experience periodic flood damages, but these damages are expected to increase.

STATEMENT OF PROBLEMS AND OPPORTUNITIES

The authorizing resolution for the Kennebec River Basin study provided the basis for identification of the problems and opportunities in the study area. Identified needs in the Kennebec River Basin were based upon a preliminary assessment of current conditions and coordination with local, State and Federal agencies. The resulting statement of desired outputs for the study were used to guide the formulation of alternative plans, assessment of impacts, and evaluation of each plans response to the planning objective. Problem and opportunity statements are as follows:

- a. Reduce future inundation damages, caused by flooding in the Kennebec River and its tributaries.
- b. Enhance, wherever possible, water quality for supply, irrigation, recreation, and aesthetic purposes in the Kennebec River Basin.
- c. Provide where possible, additional contributions to the regions water and related land recreational resources within the Kennebec River Basin.
- d. Assist in the preservation of fish and wildlife habitat and resources, and cultural and natural resources within the Kennebec River Basin.

PLAN FORMULATION

PLANNING CONSTRAINTS

Planning constraints are conditions imposed upon the planning process that limit the range of feasible alternatives available to the planner. These constraints may consist of legal, social, and environmental factors of such importance that violating them would compromise the entire planning effort.

One such policy constraint on the planning process results from the 1983 Maine Rivers Act approved June 17, 1983. This Act provides special protection for various reaches of rivers, because their existing state provides unparalleled natural and recreational value, and irreplaceable social/economic benefits to the people. This Act prohibits the construction of new dams on these rivers and stream segments without the specific authorization of the Legislature.

Flood control reservoirs on the Sandy and Carrabassett Rivers are one of the alternatives considered in this study. Both of these rivers are protected under the Maine Rivers Act. The State requested that we ignore this planning constraint while conducting our investigation.

ALTERNATIVES CONSIDERED

To prevent or reduce flooding and associated damages, several types of protection were considered: structural, nonstructural, and automated flood warning systems and hydropower storage reservoir reregulation. Automated flood warning systems and reservoir reregulation, although nonstructural, were considered a separate category in this study. Structural and nonstructural measures differ in that structural measures affect the flood waters while nonstructural measures affect activities in the floodplain.

Structural

Channel improvements were not investigated along the Kennebec River because the river has a relatively flat slope and depths of flooding are quite high (20 to 30 feet). Also, this river has a wide floodplain area that generally spans the valley cross section. It is felt that required channel improvements would be quite extensive and for those areas having the highest damage potential, channel improvements do not appear to be economically feasible.

Structural alternatives investigated include flood control reservoirs on the Sandy and Carrabassett Rivers and local protection projects in the 12 communities selected for study. The local protection projects consist of earthen dikes and/or reinforced concrete flood walls. Local protection projects providing both 50 and 100-year levels of protection were considered.

Nonstructural

Two methods of nonstructural floodproofing were investigated. These methods are detailed in "Floodproofing Regulations", Document No. EP-1165-2-314, U.S. Army Corps of Engineers, June 1972. These methods are:

1. Raise the structure and build-up the existing foundation walls to an elevation above the 100-year flood elevation.
2. Install closures for openings which will provide seals, thus dry flood-proofing the structures.

Automated Flood Warning System

An automated flood warning system consists of a series of remotely-located precipitation and/or stream flow gages that report to a computer. The computer gives information on predicted peak flood stage and the time to the peak stage. This information, through the application of a preparedness plan, can be translated into what would be expected to occur at individual communities in the Kennebec River Basin. Flood warning is not a solution to flooding; it can help reduce damages and potentially save lives.

Hydropower Reservoir Reregulation

Storage reservoirs are used in hydropower operations to store excess water during high flow periods for later release and use during low flow periods, thus, ensuring a minimum dependable hydropower generation. When storage reservoirs are drawn down for hydropower generation, their added ability to store storm runoff provides a degree of incidental flood control. The degree of flood control is a function of the percent of time, and amount, the reservoir is drawn down in its hydropower generation. Reservoir reregulation would involve the utilization of "seasonal guide curves" which would maximize the incidental flood control potential of the storage reservoirs, while at the same time not impacting their hydropower function.

METHOD OF EVALUATION

The reconnaissance phase study develops and documents the information necessary to determine if there is Federal interest in a feasibility investigation. A Federal regulation requires cost-effective alternatives where the annual benefits provided by a project equal or exceed the annual cost of constructing the project. Since project feasibility is highly sensitive to hydrologic and economic analysis, a considerable amount of the study effort was dedicated to developing adequate detail in these areas. The analyses performed are documented and discussed in the following sections.

Hydrologic Design Criteria Utilized

Discharge Frequencies

Earliest streamflow data for the Kennebec River dates back to the 1890's with some unofficial data back in the early 1800's. Early data were recorded by dam operators on the river, principally the Hollingsworth and Whitney Company on the river at Waterville, Maine. The U.S. Geological Survey (USGS) began installing gaging stations in the basin in the early 1900's and have operated a system of gaging stations, at various sites and periods of time, continuously to date. USGS stations, pertinent to the analysis of Kennebec River floods and their respective periods of record, are listed in Table 8.

Peak discharge frequencies were developed for the Kennebec River and its Tributaries by analysis of the long term gaging stations at Waterville, Bingham, Mercer, North Anson, Pittsfield, and Gardiner. The resulting peak discharge frequency curves are shown on Plate 15. Development of the curves on Plate 15 is discussed in Volume II, Hydrologic Analysis Section.

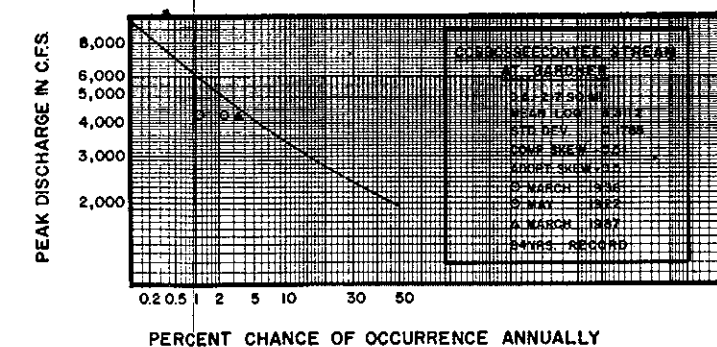
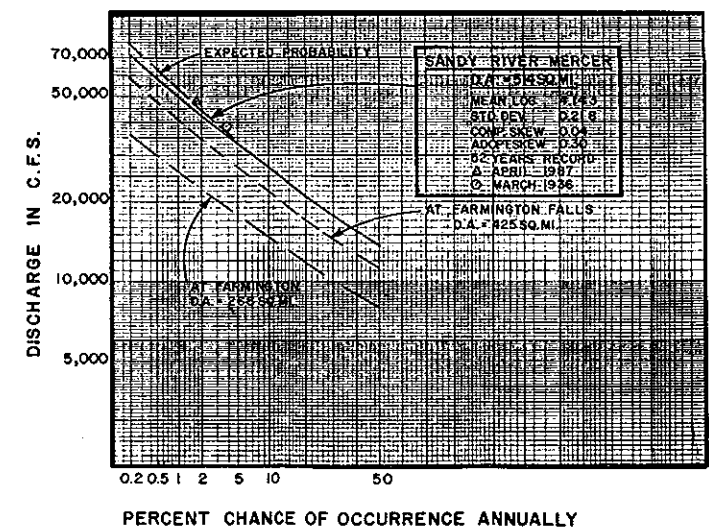
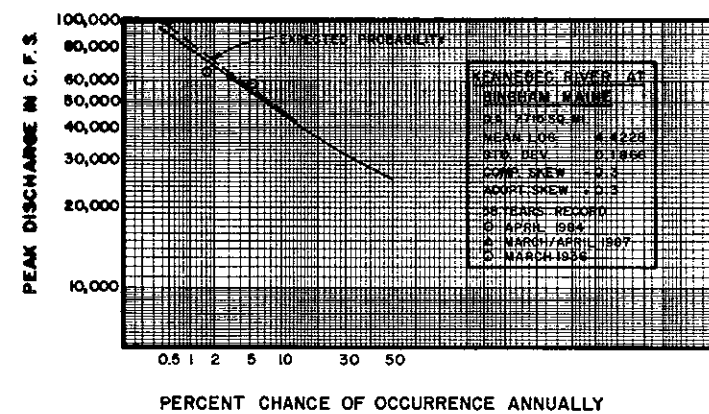
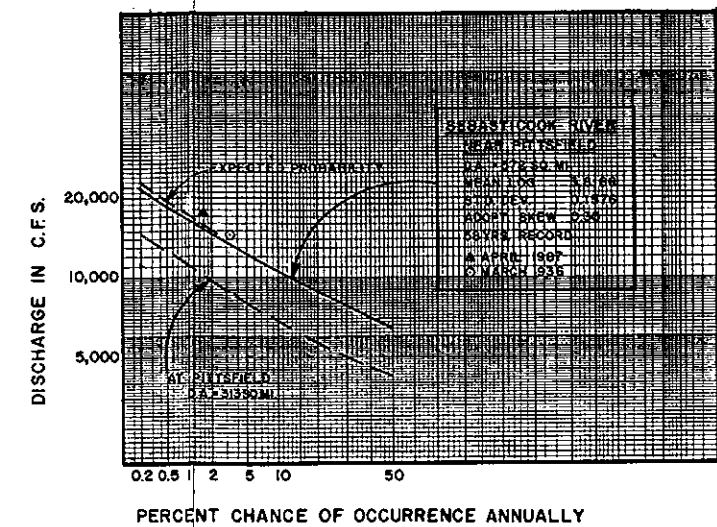
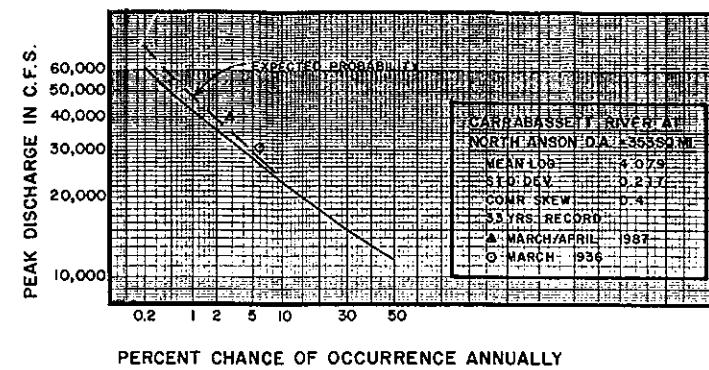
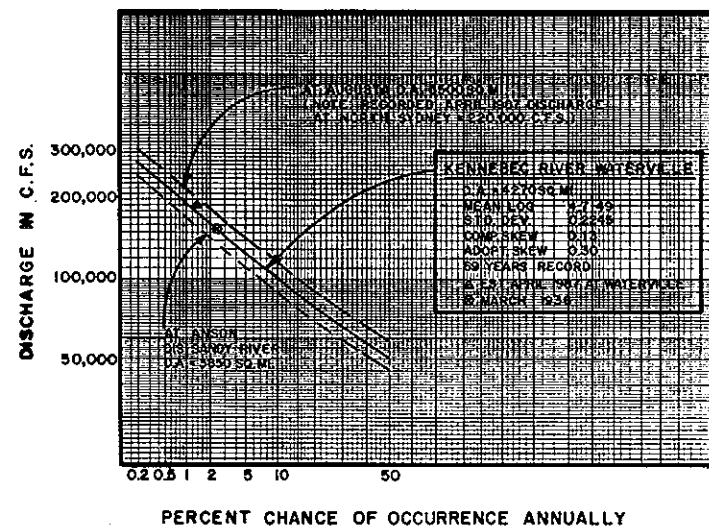
Stage Frequencies

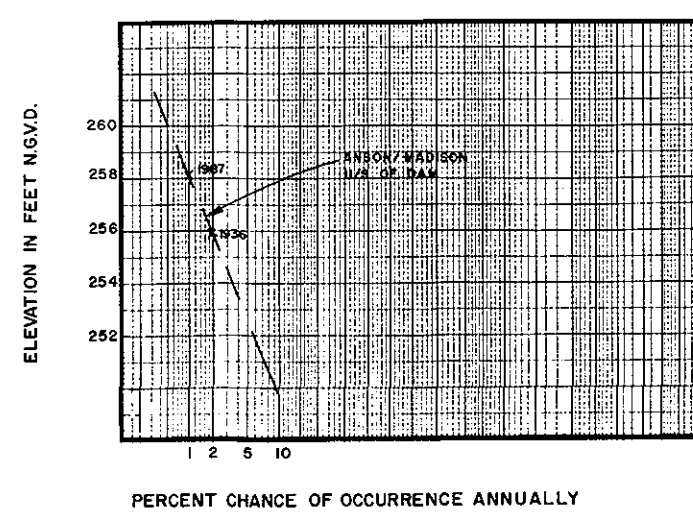
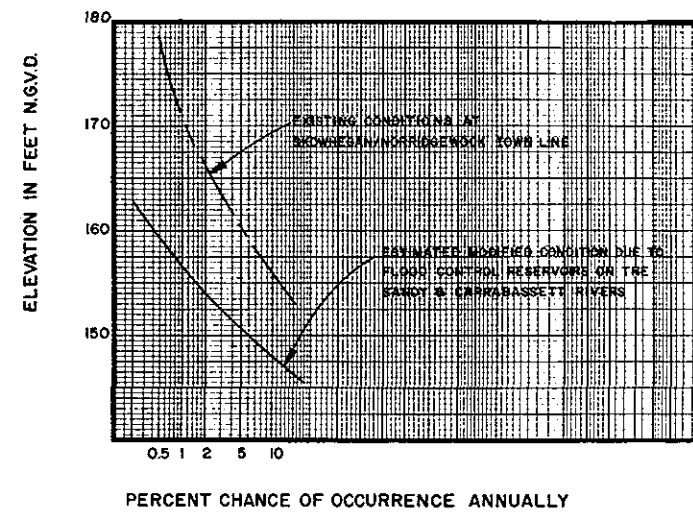
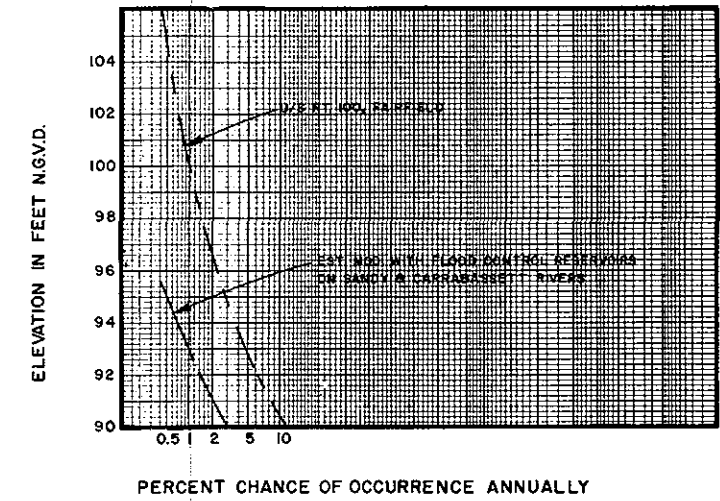
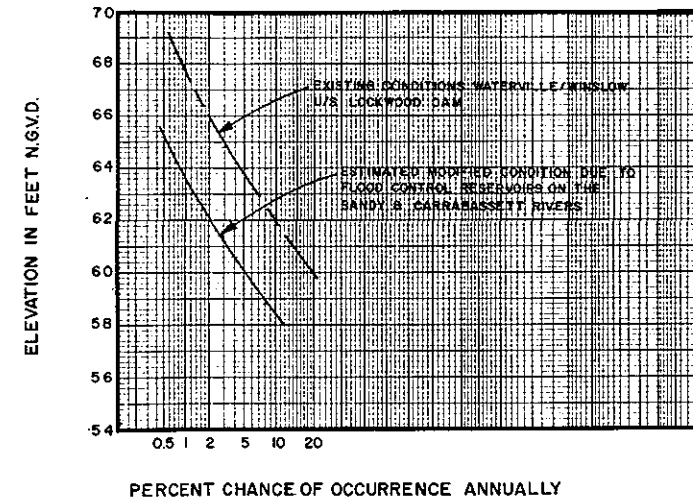
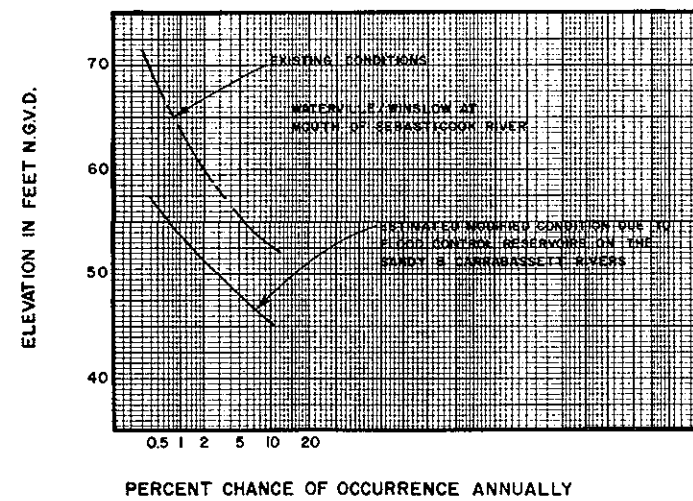
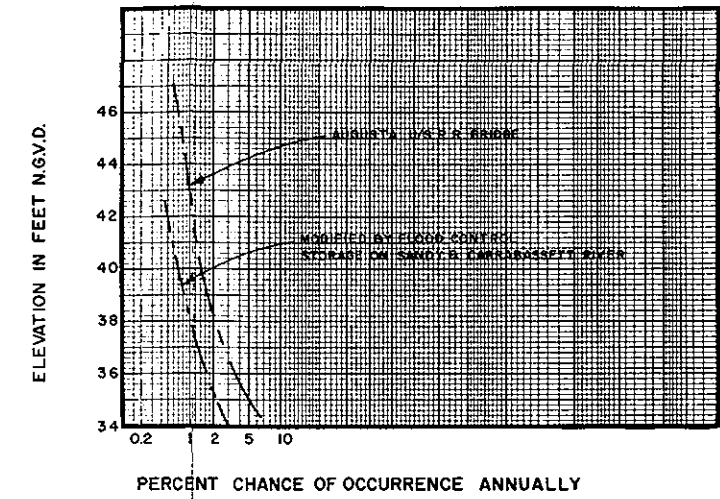
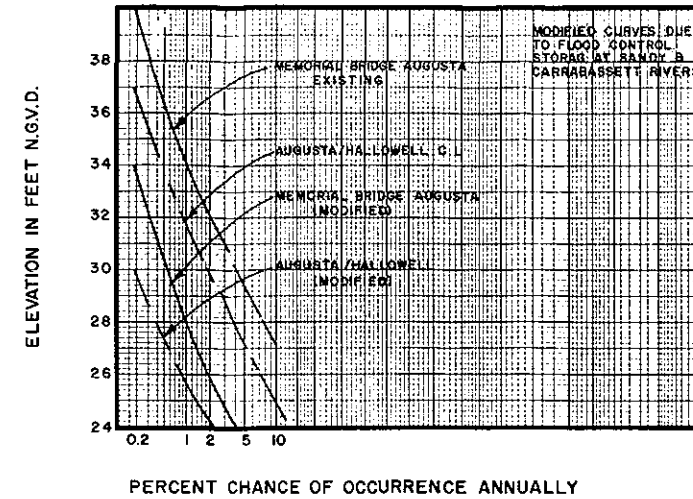
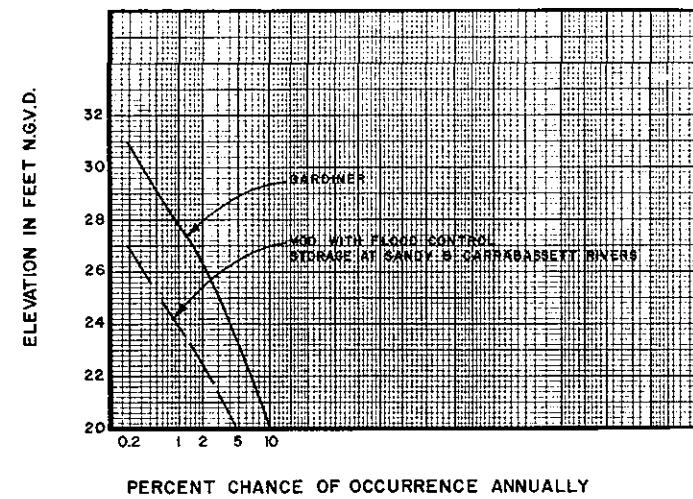
Stage frequency relationships were developed at selected damage centers throughout the watershed. These curves were used, to assess the damage potential at communities along the river. In general, curves were developed using computed discharge frequency relationships along with stage discharge curves developed from available flood profiles. The most notable exception to developing stage frequencies by this technique was the lower Kennebec generally from Augusta south to Gardiner.

Augusta to Gardiner. Due to the complex hydraulic nature of this reach of river and numerous uncertainties, stage frequencies were developed by assigning the two surveyed flood elevations (1936, 1987) Weibull plotting positions and a curve sketch using hydrologic engineering judgement. It is noted that while these curves do not differ appreciably from the elevations present in the various flood insurance studies, the development technique for the two is not consistent. Adopted stage frequency curves for Gardiner/Randolph, Hallowell and Augusta (Memorial Bridge) are shown on Plate 16. For a more detailed discussion of the hydrologic analyses performed in this reach of the Kennebec River the reader is referred to Volume II, Hydrologic Analysis Section.

Upstream of Augusta. Stage frequency relationships were developed for the following communities along the mainstem Kennebec:

Augusta (upstream Cushnoc Dam)
Waterville/Winslow
Fairfield
Skowhegan
Madison/Anson





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KENNEBEC RIVER BASIN MAINE

MAIN STEM KENNEBEC

STAGE FREQUENCY CURVES

HYDRO. ENGR. SECT.

NOV. 1988

TABLE 8
PERTINENT DATA - USGS GAGING STATIONS
KENNEBEC RIVER BASIN

<u>Station</u>	<u>Drainage Area</u> (sq. mi.)	<u>Period of Record</u>	<u>Maximum Flow</u> (cfs)	
<u>Kennebec River</u>				
at Moosehead	1,268	1919-1982	16,700 -	3 May 1974
at Forks	1,590	1901-Present	30,300 -	1 Jun 1984
at Bingham	2,715	1908-1909 1931-Present	65,200 -	1 Jun 1984
at Waterville	4,270	1891-1954	154,000 -	19 Mar 1936
at N. Sidney	5,403	1978-Present	220,000 -	Apr 1987
<u>Dead River</u>				
nr. Dead River	516	1939-1982	18,000 -	12 Sept 1954
at Forks	872	1910-1979	28,700 -	20 Mar 1936
<u>Carrabassett River</u>				
nr. North Anson	353	1926-Present	41,000 -	Apr 1987
<u>Sandy River</u>				
nr. Mercer	514	1928-1979 +1987	38,600 - 46,000 -	19 Mar 1936 Apr 1987
<u>Sebasticook River</u>				
nr. Pittsfield	572	1928-Present	17,500 -	Apr 1987

Curves at these locations, with the exception of Madison/Anson, (shown on Plate 16) were developed based on discharge rating curves developed from flood profiles presented in various flood insurance studies and adopted discharge frequency relationships. The curve at Madison/Anson was developed based on surveyed high watermarks of 1936 and 1987 and assigned plotting positions.

Farmington. Stage frequencies were developed along the Sandy River at Farmington, Maine. A discharge rating curve developed during past Corps studies was utilized along with computed discharge frequencies. The curve is shown on Plate 17.

Pittsfield. There are no detailed flood profiles or topographic mapping available for the Sebasticook River in Pittsfield, Maine. Development of stage frequency curves was reliant on surveyed flood elevations for the 1936 and 1987 flood events, hydrologic engineering judgement and the limited data presented in a Phase I inspection report for Pioneer Dam in Pittsfield. Estimated curves are shown on Plate 17.

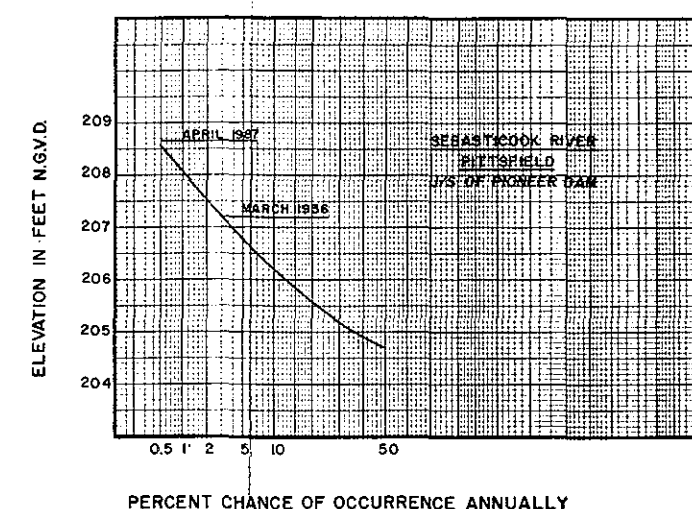
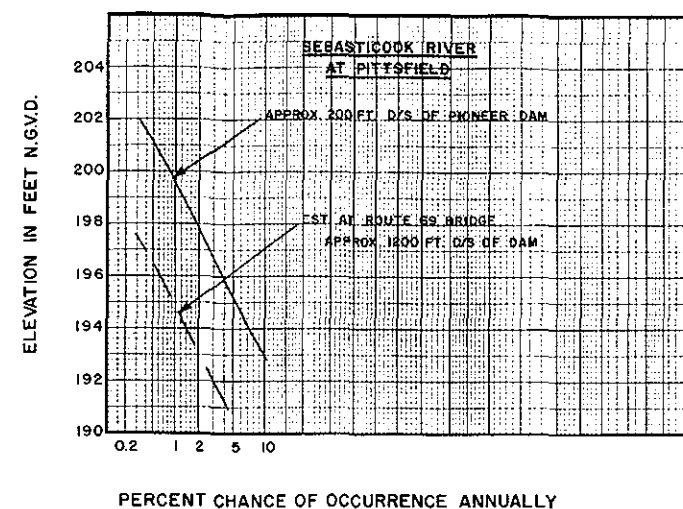
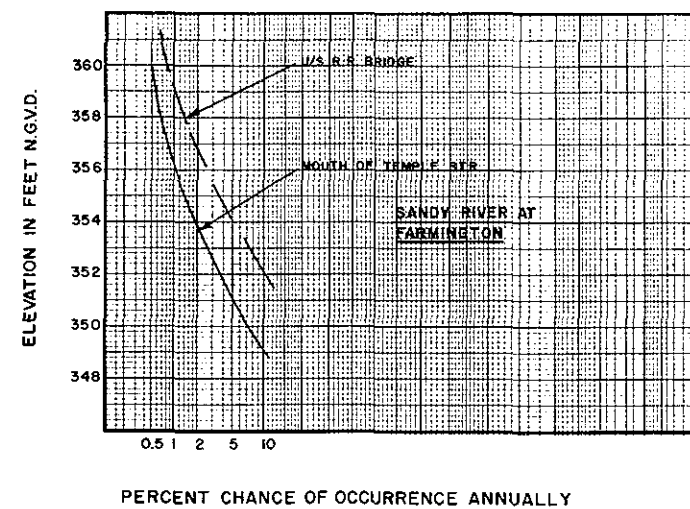
Estimating Project Costs

A Federal regulation requires cost-effective alternatives where the annual cost of implementing the project does not exceed the annual benefits provided by the project. The costs of implementing the projects were initially calculated to a degree of accuracy considered sufficient in determining the economic feasibility. For instance, if it could be shown that a project was not economically justified by calculating only a portion of the project cost then no additional cost analysis was warranted. Additional cost analysis was performed only for projects that appeared economically justified in the initial estimate.

The first time costs of all the structural alternatives considered were annualized over a period of 100 years. The nonstructural alternatives were annualized over a period of 50 years and the automated flood warning system over a period of 15 years. In each case an interest rate of 8-7/8 percent was used.

Benefit Estimation Methodology

Benefits were estimated for the different types of improvement plans by use of the following methods. **Structural plans: Reservoirs-** Annual losses were compared under the with and without project conditions for the communities affected. Natural and modified stage frequency curves were employed. Benefits to the reservoir is the difference in annual losses under the two conditions. **Dikes and Walls-** Annual losses prevented under existing conditions were calculated up to the specific level of protection (elevation) plus 50 percent of the freeboard range. **Raising of First Floor -** Annual losses to each structure were compared without the plan (first floor at existing elevation) and with the plan (first floor raised to one foot above the 100-year flood elevation). Benefits are the difference in total annual losses. **Closures -** Annual losses were estimated for each building only for those damage categories that closures would prevent. For example, contents and structure were included, but non-physical losses and grounds were not. Benefits were calculated as reduced annual losses up to the level of protection. All closure plans were evaluated at the 100-year level of protection.



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KENNEBEC RIVER BASIN MAINE
HYDROLOGIC RECONNAISSANCE REPORT
STAGE FREQUENCY CURVES AT
FARMINGTON AND PITTSFIELD

HYDRO. ENGR. SECT. NOVEMBER 1988

FLOOD CONTROL RESERVOIRS

Previous Corps hydrologic studies analyzed the component contribution of various sub-watersheds and determined the Sandy and Carrabassett Rivers to be major contributors to peak Kennebec River flows. Therefore, these watersheds were examined to determine if feasible flood control reservoir sites exist.

As previously mentioned, the purpose of a reconnaissance investigation is to identify problems, formulate an alternative solution to the problem, determine Federal interest in further evaluations and identify a potential local sponsor. Due to the limited time available during a reconnaissance investigation an analysis of several alternative reservoir sites on the Sandy and Carrabassett Rivers was not possible. In order to determine the sites for the flood control reservoirs to be evaluated, a methodology was developed that would maximize flood control benefits of the reservoirs and temporarily ignore some cost considerations.

The ideal site for a flood control reservoir to maximize flood control benefits, and therefore give the best opportunity for economic justification, has certain hydrologic and physical characteristics. The site should allow the reservoir to have a significant amount of storage while controlling a major portion of the drainage basin. The Corps has constructed 35 dams within the New England Division. In studies during the design of this system of reservoirs it was found that flood control storage capacity from 6 to 8 inches of runoff from the contributing watershed was a reasonable amount of storage for flood control purposes. The site should be located as close as possible to major damage areas thus causing a significant flood stage reduction and provide maximum benefits. The site should be located in an area where the existing natural topography has two hills relatively close together minimizing the length of dam required.

Sites were selected on the Sandy and Carrabassett Rivers that met the stated criteria and gave the best opportunity for economic justification. Investigation of reservoir sites further upstream from the sites chosen would cause less flood stage reduction in the damage areas thus lowering economic benefits of the reservoirs.

Sandy River Reservoir Site

The Sandy River, with a total drainage area of 596 square miles has been investigated for possible reservoir sites in the past. During the NENYIAC studies this watershed was investigated for a potential hydropower storage project. The Greenleaf dam project site, with a drainage area of 513 square miles, is located about 9 miles above the mouth of the river between the communities of Starks and Mercer. A reservoir at this site would control 86 percent of the drainage basin. In current studies this site was investigated for use as a potential flood control reservoir. The Greenleaf dam, as proposed for hydropower use, would have been about 125 feet high and have impounded approximately 160,000 acre-feet of storage. Therefore, utilizing 160,000 acre-feet for flood control storage would result in 5.9 inches of runoff from the upstream watershed. The main dam would consist of a rolled earth section about 3,400 feet long. In addition, four earth dikes, of moderate height, would be required to close the reservoir

perimeter. As originally planned, the Greenleaf project would have had a remote spillway located in a low saddle which would have discharged into Lemon Stream. Spillway length and maximum surcharge have not been determined; however, placing spillway crest at elevation 320 feet NGVD would provide the 160,000 acre-feet of flood control storage and establishing top of dam at elevation $340 \pm$ feet NGVD would allow for 20 feet of spillway design surcharge and freeboard. This reservoir would require land taking of about 4,500 acres at spillway crest elevation. The proposed site is shown on Plate 18.

Carrabassett River Reservoir Site

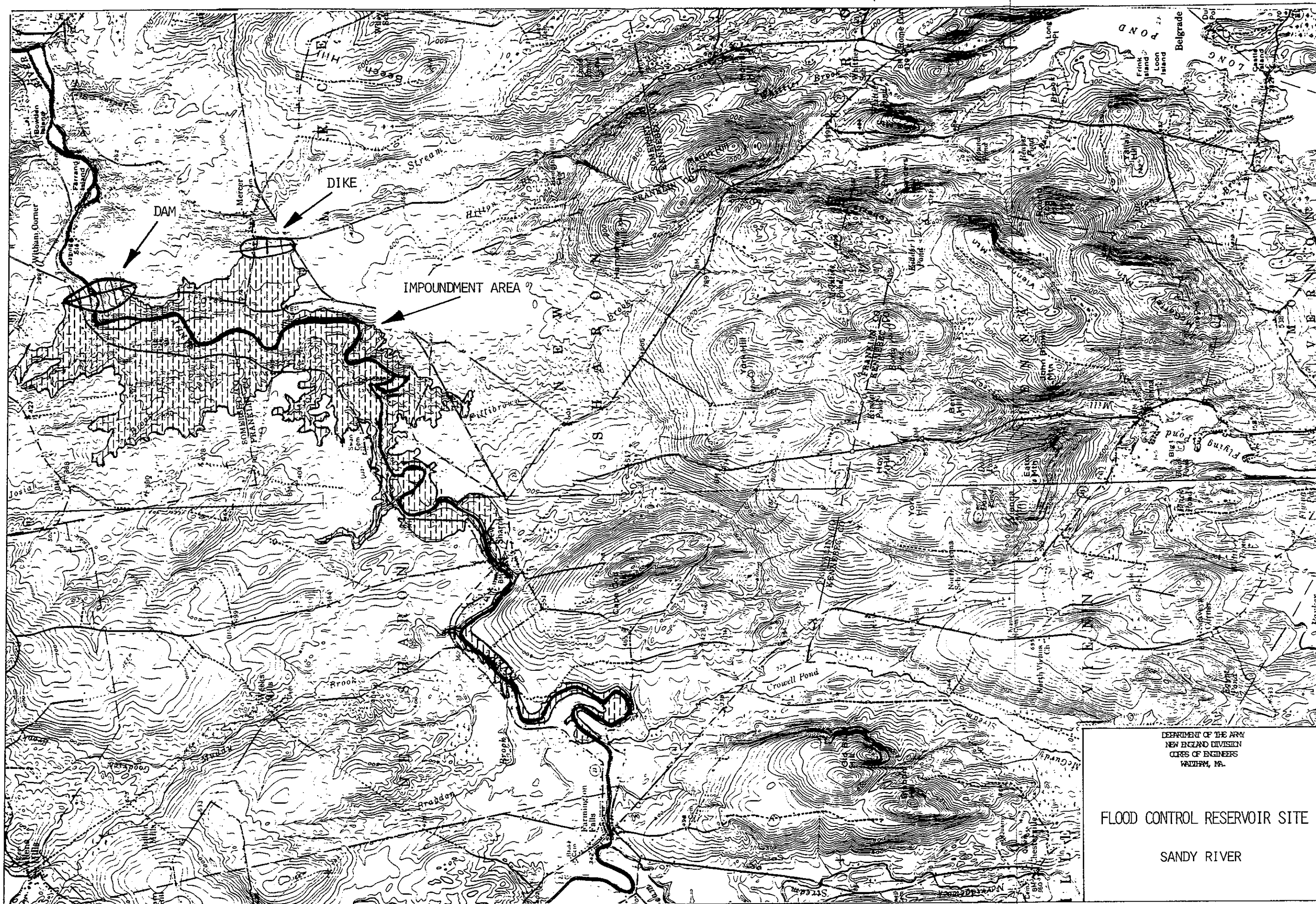
The Carrabassett River with a total drainage area of 401 square miles was reviewed. Starting at the mouth of the river at the community of North Anson, the Carrabassett appears to be relatively steep, falling rapidly to the Kennebec. Proceeding upstream the river slope flattens somewhat and the river appears to have relatively low overbanks. Within this area, due to the natural topography, there does not appear to be any well defined dam site.

Proceeding upstream, about 3 miles past the USGS gaging station, the river passes between two large hills along the border between the towns of New Portland and Embden, about 1 mile above Big Brook; this appears to be a relatively well defined dam site. About one mile upstream from this location a major tributary (Gilman Stream, DA = 94 square miles) joins the Carrabassett. Therefore, a reservoir upstream of the confluence with Gilman Stream would lose much of its effectiveness. Lemon Stream (DA = 34 square miles) enters at New Portland and the Carrabassett at Kingsfield has a drainage area of 165 square miles. All of these factors lead to the most logical site upstream of the gage.

Analysis of the USGS 20-foot contour mapping indicates that the river has an invert of about 330 feet NGVD at this location, and a drainage area of about 350 square miles. Therefore, to provide storage equivalent to 6 inches of runoff (112,000 acre-feet) from the upstream watershed for flood control, a dam about 90 feet high (330 to 420 feet NGVD) would have to be constructed. Storage capacity between 330 to $405 \pm$ feet NGVD would represent about 6.5 inches of runoff. Allowing 15 feet for spillway design, surcharge and freeboard would put top of dam at elevation 420 feet NGVD. This dam would be about 1,800 feet long with an estimated reservoir area at spillway crest of 8,000 acres. The proposed site is located on Plate 19.

Flood Control Reservoir Cost Estimates

The "Methodology For Areawide Planning Studies" computer program (MAPS) was used to estimate construction costs for the two flood control reservoirs considered. MAPS was developed by the Environmental Laboratory of the U.S. Army Engineer Waterways Experimental Station to assist Corps personnel in screening water resource related alternatives. The cost estimating methods used in MAPS combined with engineering judgement produce reasonably accurate estimates. Unit prices contained in the MAPS program were updated to reflect the magnitude and complexity of the work to be accomplished as well as the locality where the proposed construction would be done. Cost estimates for the two reservoir sites are shown in Tables 9 and 10.



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FLOOD CONTROL RESERVOIR SITE

SANDY RIVER

As previously mentioned some cost items were not included in the initial economic analysis. One of the most difficult estimates to develop when analyzing flood control reservoirs is real estate cost. Real estate costs include purchase of individual properties, relocation of some homes, and cemeteries, and flow easement acquisition. Since the development of these real estate estimates would require a great deal of the resources available for the reconnaissance investigation it was decided that these costs would only be developed for reservoirs that appeared economically justified in an initial benefit assessment. Alternatives that had benefit cost ratios less than unity without the inclusion of these costs would therefore have B/C ratios only lowered when these costs were incorporated.

TABLE 9
COST ESTIMATE FOR CARRABASSETT RIVER RESERVOIR

SUMMARY OF DAM COSTS

Stripping Costs	\$122,000
Clearing and Grubbing Costs	\$3,000
Foundation Excavation Costs	\$93,000
Embankment Costs	
Impervious Material	\$1,790,000
Pervious Material	\$2,370,000
Rip Rap Protection	\$1,130,000
Toe Drain Cost	\$54,000
Outlet Works	\$2,270,000
Spillway	
Spillway Overflow Structure/Channel	\$41,600,000
Spillway Bridge	\$2,860,000
 TOTAL CONSTRUCTION COSTS FOR DAM	 <u>\$52,291,000</u>
 <u>RELOCATION COSTS</u>	
Secondary Highways	\$1,620,000
Roadway Bridges	\$1,040,000
 TOTAL RELOCATION COSTS	 <u>\$2,660,000</u>
 SUB TOTAL	 \$54,951,000
CONTINGENCY FACTOR (20 PERCENT)	\$10,990,000
 TOTAL PROJECT CONSTRUCTION COST	 <u>\$65,941,000</u>

TABLE 10
COST ESTIMATE FOR SANDY RIVER RESERVOIR

SUMMARY OF DAM COSTS

Stripping Cost	\$257,000
Clearing and Grubbing Cost	\$5,000
Foundation Excavation Cost	\$146,000
Earth Embankment	
Impervious Material	\$5,060,000
Pervious Material	\$7,461,000
Rip Rap Protection	\$5,090,000
Toe Drain Cost	\$86,000
Outlet Works Cost	\$4,820,000
 TOTAL CONSTRUCTION COST FOR DAM	 <u>\$22,925,000</u>

SUMMARY OF DIKE COSTS (Northwest Dike with Spillway and Southeast Dike)

Spillway	
Spillway Overflow Structure	\$26,100,000
Spillway Bridge	\$2,190,000
Stripping Costs	\$137,000
Clearing And Grubbing Costs	\$3,000
Foundation Excavation Costs	\$126,000
Earth Embankment	
Impervious Material	\$1,004,000
Pervious Material	\$832,000
Rip Rap Protection	\$453,000
Toe Drain Costs	\$1,189,000
 TOTAL CONSTRUCTION COSTS FOR DIKES/SPILLWAY	 <u>\$31,729,000</u>

SUMMARY OF SPILLWAY CHANNEL COSTS

Clearing and Grubbing Costs	\$5,000
Earthwork Costs	\$1,000,000
Lining Costs	\$6,520,000
Bridge Costs	\$1,170,000
 TOTAL CONSTRUCTION COST FOR SPILLWAY CHANNEL	 <u>\$8,695,000</u>

RELOCATION COSTS

Secondary Highways/Roadway Bridges	<u>\$2,500,000</u>
SUB TOTAL	\$65,849,000
CONTINGENCY FACTOR (20 PERCENT)	\$13,170,000
TOTAL PROJECT CONSTRUCTION COST	<u>\$79,019,000</u>

Economic Evaluation Of The Flood Control Reservoirs

The flood control reservoirs on the Sandy and Carrabassett Rivers when acting in tandem, results in approximately a 77% reduction of flood losses. Annual losses were compared under the with and without project conditions for the 8 communities studied that would benefit from the flood control reservoirs. The natural and modified stage-frequency curves shown on Plate 16 were employed. Benefits to the reservoirs are the difference in annual losses under the two conditions. Table 11 below shows the benefits that would accrue to each town and also the percent reduction in flood losses attributed to the reservoirs.

TABLE 11
RESERVOIR PLAN

<u>Location</u>	<u>Annual Losses w/o Reservoirs</u>	<u>Annual Losses w/ Reservoirs</u>	<u>Annual Benefits</u>	<u>% Reduction in Losses</u>
Skowhegan	\$69,000	\$100	\$69,300	99 %
Waterville	80,100	4,400	75,700	95 %
Winslow	118,300	10,900	107,400	91 %
Fairfield	55,000	3,500	51,500	94 %
Augusta	209,400	15,800	193,600	92 %
Hallowell	117,100	13,900	103,200	88 %
Randolph	110,800	41,100	69,700	63 %
Gardiner	425,000	178,100	246,900	58 %
<u>TOTAL</u>	<u>\$1,185,100</u>	<u>\$267,800</u>	<u>\$917,300</u>	<u>77 %</u>

When comparing the annual benefits to the annual costs of construction, flood control reservoirs were not found to be economically justified. The costs far outweigh the expected benefits. Table 12 shows the cost, benefits and the resulting benefit-cost ratio of the alternatives. Annualized costs were calculated using a 100-year project life and 8-7/8 percent interest.

TABLE 12
ECONOMIC FEASIBILITY - FLOOD CONTROL RESERVOIRS

<u>First Cost</u>	<u>Annual Cost</u>	<u>Annual Benefits</u>	<u>B/C Ratio</u>
\$144,900,000	\$13,000,000	\$900,000	0.07

Environmental Considerations Of Flood Control Reservoirs

Both general and site specific environmental considerations of the flood control reservoirs investigated are discussed in Volume II of this report. The discussion presented is for information only since the flood control reservoirs were not economically justified.

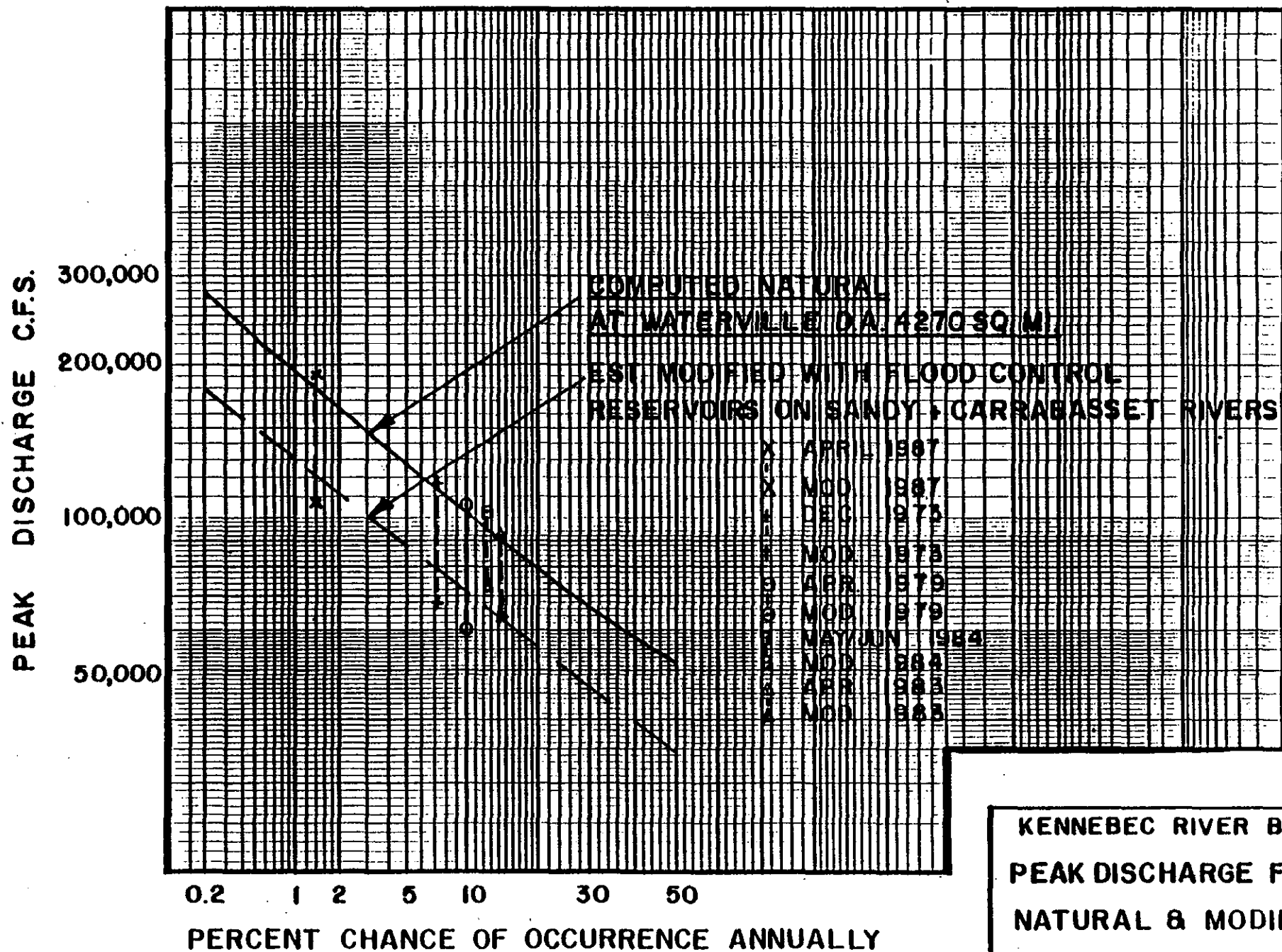
LOCAL PROTECTION PROJECTS

Hydrologic analyses were performed and information on historic floods were utilized to determine potential damage areas in the communities selected for this study. In addition, each community was asked to provide a street map illustrating every street that water affected during the 1987 event. Inventories of structures and their elevations were conducted to determine the extent and damages caused by flooding. Measures were then investigated to determine their individual applicability to solving/reducing the flood problems. Measures investigated are discussed as follows.

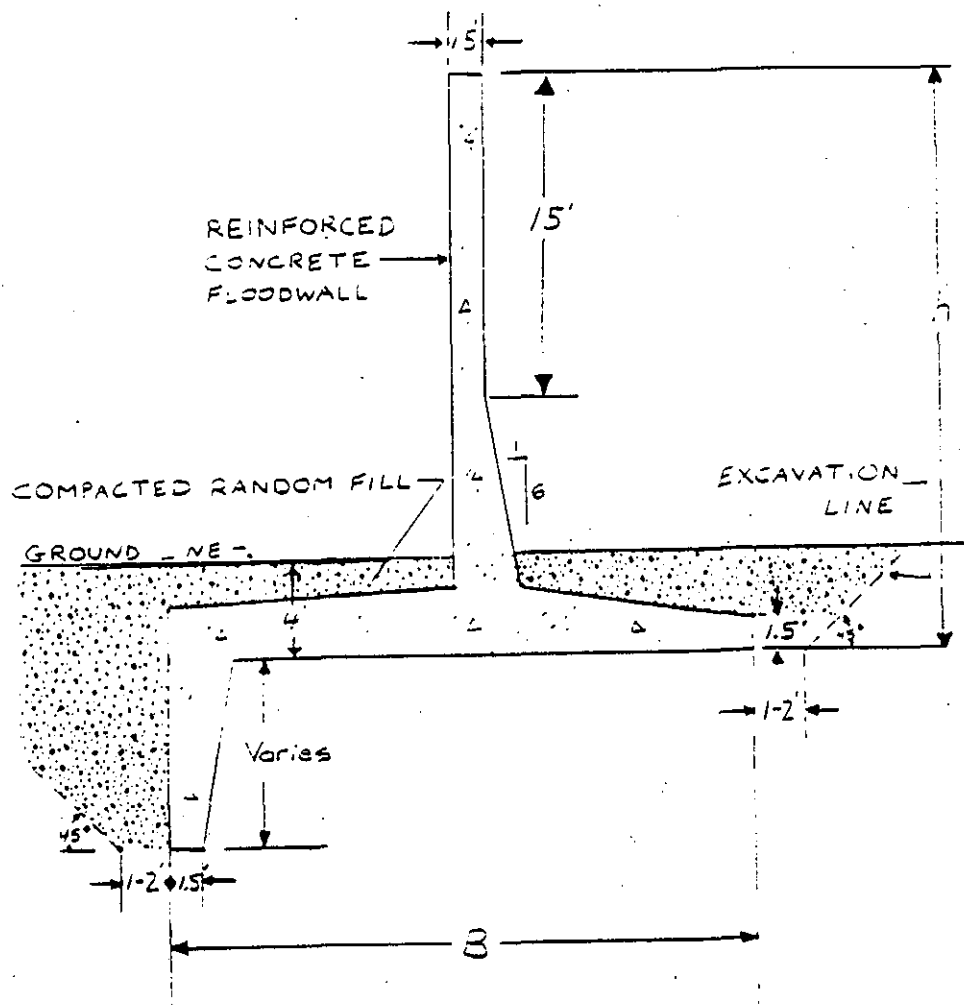
General Design

Flood Walls and Earthen Dikes

The design heights for walls and dikes were determined using existing topographic mapping and the stage frequency curves discussed in the previous section of this report. General design features for the two types of protection are shown in Plates 21 and 22. Walls and dikes providing 50 and 100-year levels of protection were both considered for communities in the study. In each case the construction cost estimates were calculated to a degree of accuracy that was sufficient in determining the economic feasibility of the proposed project. The first time costs generally include only the cost of site preparation and in place material costs with 25 percent added for contingencies and 20 percent for engineering, design, supervision and administration. The costs associated with real estate acquisition, interior drainage, closures and maintenance were generally not included. Including costs for these items would only lower the already small Benefit/Cost ratios. Unit material costs used in the cost estimates are shown in Table 13.



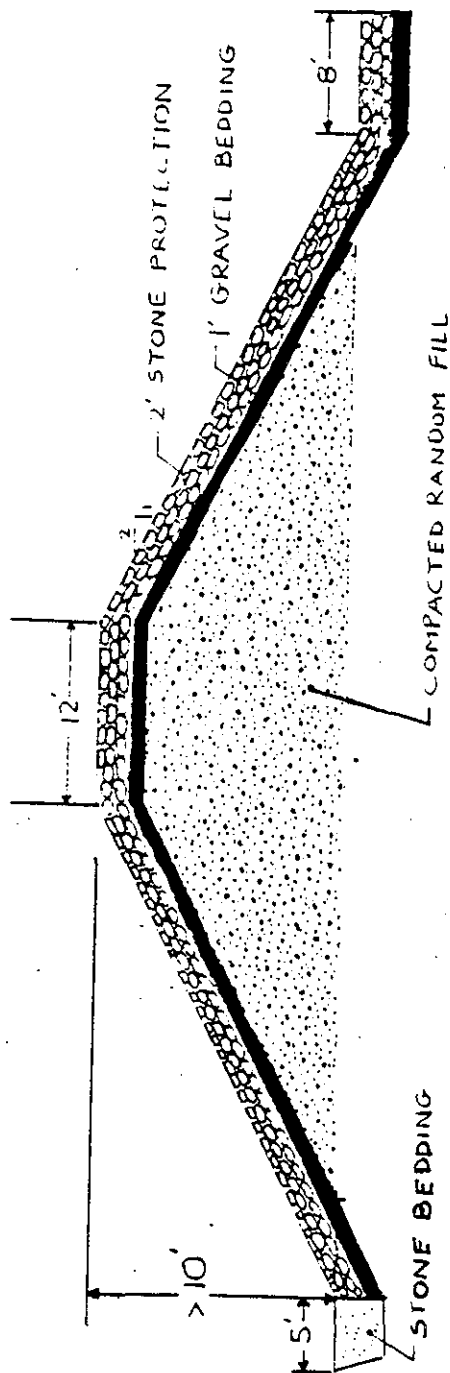
**KENNEBEC RIVER BASIN
PEAK DISCHARGE FREQ.
NATURAL & MODIFIED**



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WALTHAM, MA.

REINFORCED CONCRETE FLOOD WALL

TYPICAL CROSS SECTION



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 NEW ENGLAND DIVISION
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 WATZUM, MA.

EARTHEN DIKE

TYPICAL CROSS SECTION

TABLE 13
FLOOD WALL AND DIKE UNIT INPLACE COSTS

<u>ACTIVITY</u>	<u>COSTS</u>
Clearing and Grubbing	\$0.05 sq. ft.
2 feet Stone Protection	\$40.00 cu. yd.
Compacted Gravel Fill	\$20.00 cu. yd.
Compacted Random Fill	\$10.00 cu. yd.
1 foot Stripping	\$2.00 sq. yd.
Dry Excavation	\$12.00 cu. yd.
Reinforced Concrete	\$300.00 cu. yd.

Nonstructural Alternatives

A field survey was conducted in order to determine the number of occupied buildings within each community flooded by the 100-year (1 percent chance of occurrence) storm event; and to obtain first floor elevations and low corner elevations for these buildings. The field data collected was then grouped according to usage (residential, commercial, etc.) and to the type of building materials (masonry and wood). Floodproofing estimates were then developed according to the structure types.

Two methods of floodproofing were investigated. These methods are detailed in "Flood-Proofing Regulations, Document No. EP-1165-2-314, U.S. Army Corps of Engineers, June 1972". These methods are:

- 1) Raise the structure and build-up the existing foundation walls to an elevation above the regulatory flood datum. Existing structures with basements would be required to relocate any utilities, and the basement would then be filled in with suitable material.
- 2) Install closures for openings which will provide essentially dry barriers or seals. This is a Type 2 Closure and would consist of aluminum flood shields with stiffeners, watertight gaskets and structural frames permanently anchored to each building. Closures for windows and doors will be similar to those shown on Plates 23 thru 28.

The estimate for each community is also based on the types of structures within the flood hazard area. These classifications generally consist of residential, commercial, or industrial usage; which is detailed further to include the structures building material, ie. wood or masonry, which was determined by visual identification. Since the field survey was not required to determine the existence, size or structural capacity of basement walls, all the floodproofing methods described herein are based on the premise that if a basement exists, it will withstand any hydrostatic pressure and prevent the passage of water into the interior space. The floodproofing estimate for residential construction is divided into three categories: wood construction, 1-1/2 stories or less; wood construction, 2 stories or more; and masonry construc-

tion. Wood construction of 1-1/2 stories or less will allow the structure to be jacked with the foundation walls built up to a level above the regulatory flood datum. Wood construction of 2 stories or more does not allow this method, generally due to the structure height as well as the larger square footage for each level. The masonry residential buildings encountered in the twelve communities are predominately larger apartment buildings, but the estimate has been modified to reflect smaller buildings when they were encountered.

The estimate for the commercial/storefront buildings is divided into two types of construction - masonry and wood. The masonry construction consists of brick, cement block and several structures constructed from granite. Buildings which did not fall into the above categories were classified as public works and assembly buildings which were primarily masonry construction. A summary of nonstructural costs according to building type are shown in Table 14.

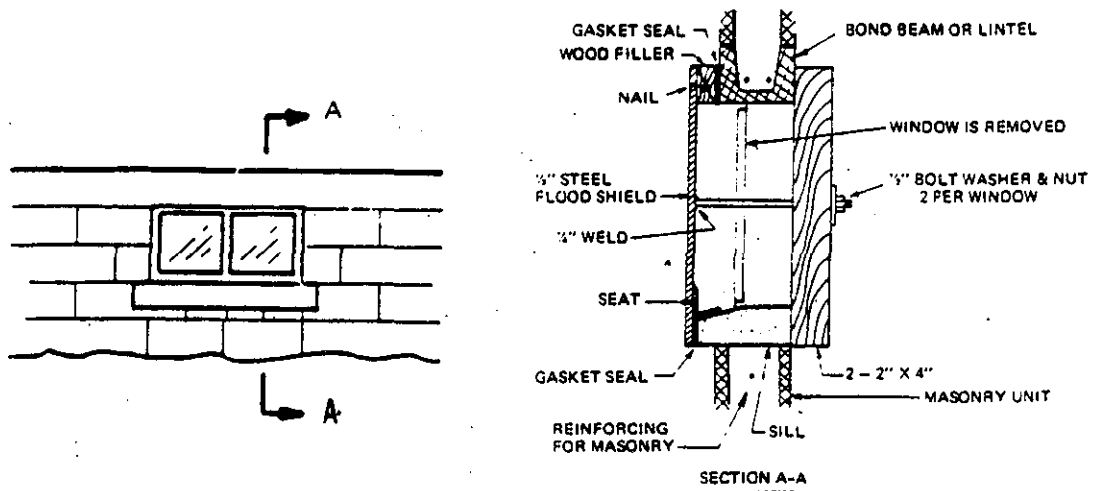
Prior to implementing any of the floodproofing methods described herein, a detailed investigation to determine the exact construction method, design strength and present condition of the structures' foundation and bearing walls would be required. This detailed investigation would provide critical information in determining the structural ability of each building to withstand the hydrostatic pressure encountered during a flood as well as structural modifications that may be required in order to attach framing for the closures to each structure.

TABLE 14
TYPICAL NONSTRUCTURAL COSTS

<u>ACTIVITY</u>	<u>COST</u>
Raise Structure (1-1/2 stories max)	\$38,000
Closures	
Residential-Wood	\$23,000
Residential-Masonry-Apt Bldg	\$54,000
Residential-Masonry-Single Family	\$27,000
Commercial-Masonry	\$36,000
Commercial-Wood	\$34,000
Public-Masonry	\$36,000

Evaluation of Local Protection Projects

In the following analyses of the 12 communities selected for study, individual damage areas and the areas to be protected are examined in terms of floodplain activities, floodplain characteristics, recurring losses and annual losses. Construction costs and benefits are estimated for each local improvement plan, both structural and nonstructural, and a benefit/cost ratio and net benefits are calculated for each. Construction costs for structural alternatives were

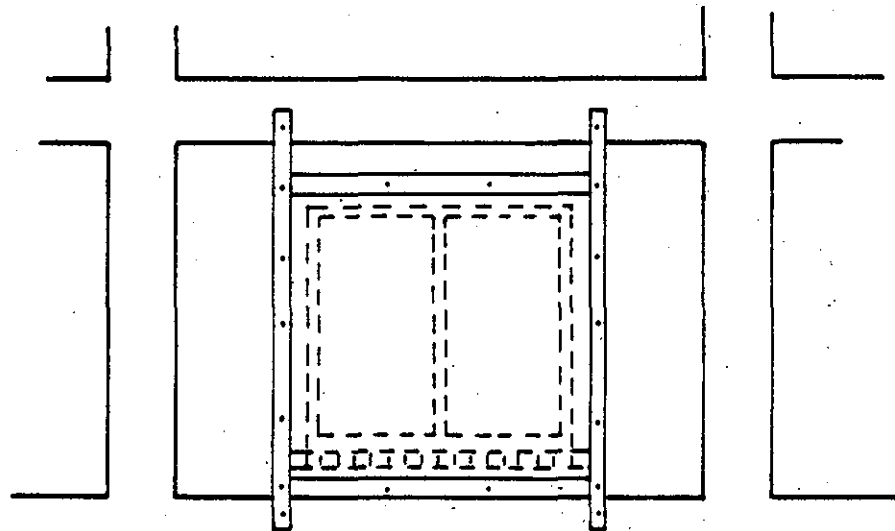
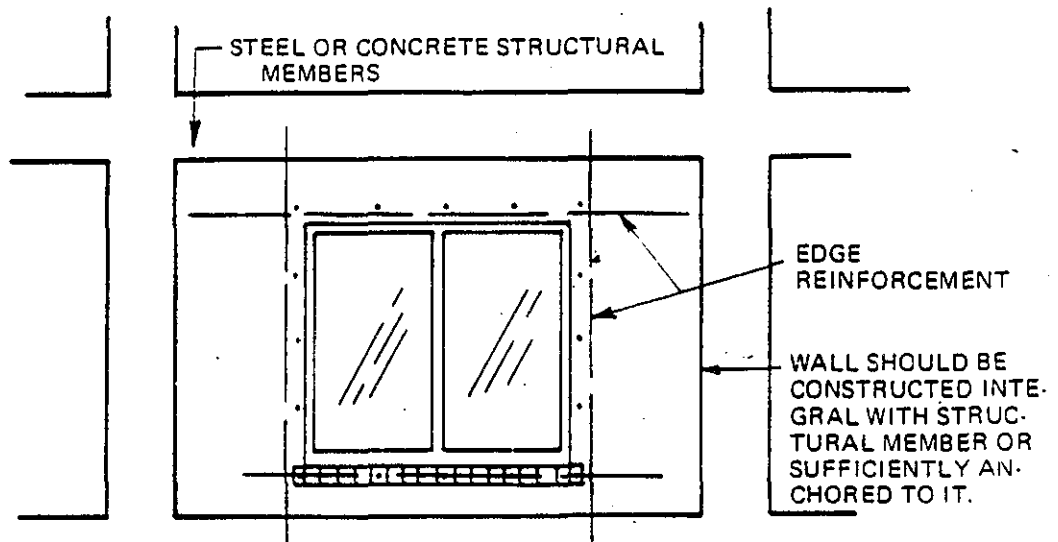


**CLOSURE PANEL FOR BASEMENT WINDOW
FOR SMALL WINDOWS AND SHALLOW DEPTH OF FLOODING**

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WATZFM, MA.

TYPICAL CLOSURE PANEL

BASEMENT WINDOWS



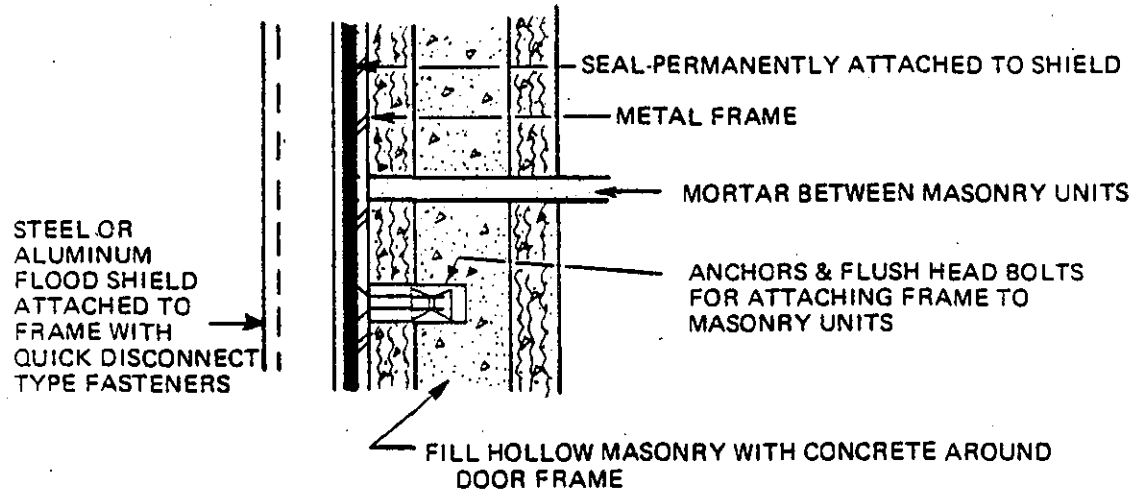
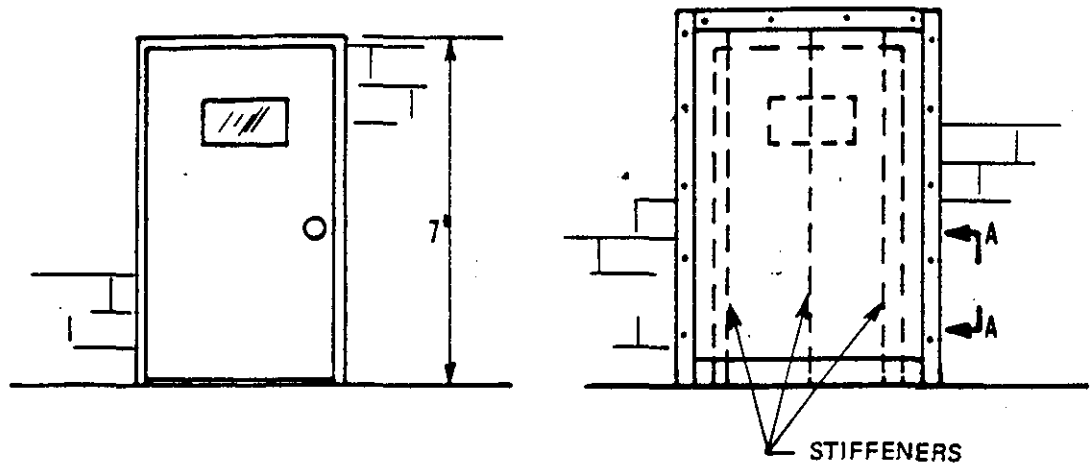
REINFORCING FOR BOND BEAMS AND VERTICAL STEEL MAY BE REDUCED IF FORCES ARE TRANSMITTED TO STRUCTURAL MEMBERS BY THE FLOOD SHIELD FRAME AS SHOWN ABOVE.

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WATZON, MA.

BOND BEAMS
VERTICAL REINFORCEMENT

LARGE OPENINGS

TYPICAL DOOR



SECTION A-A

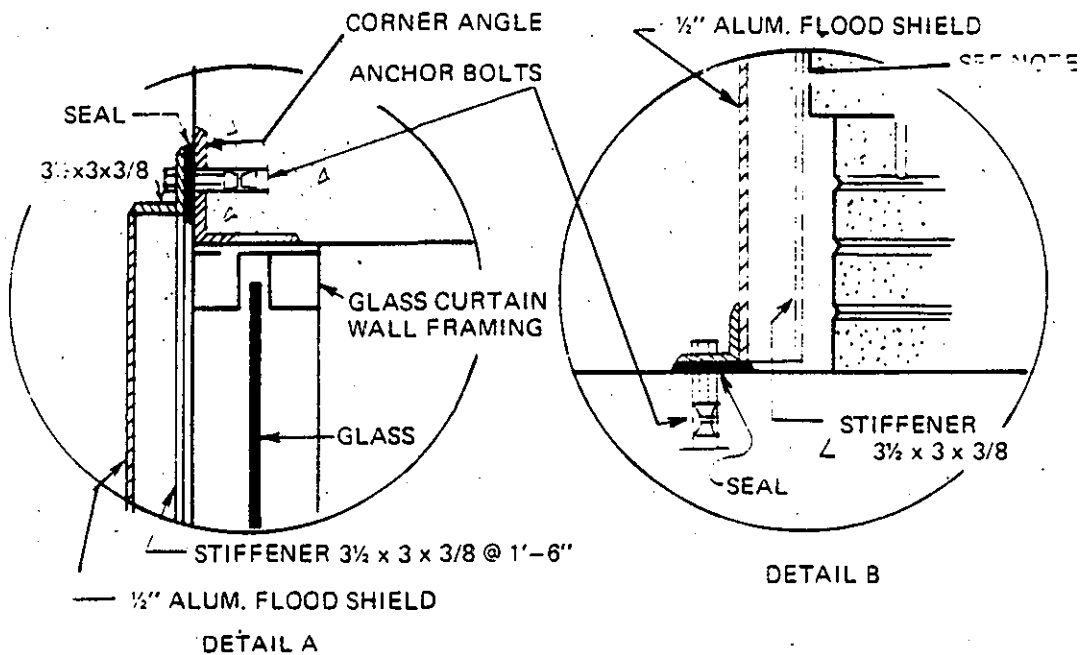
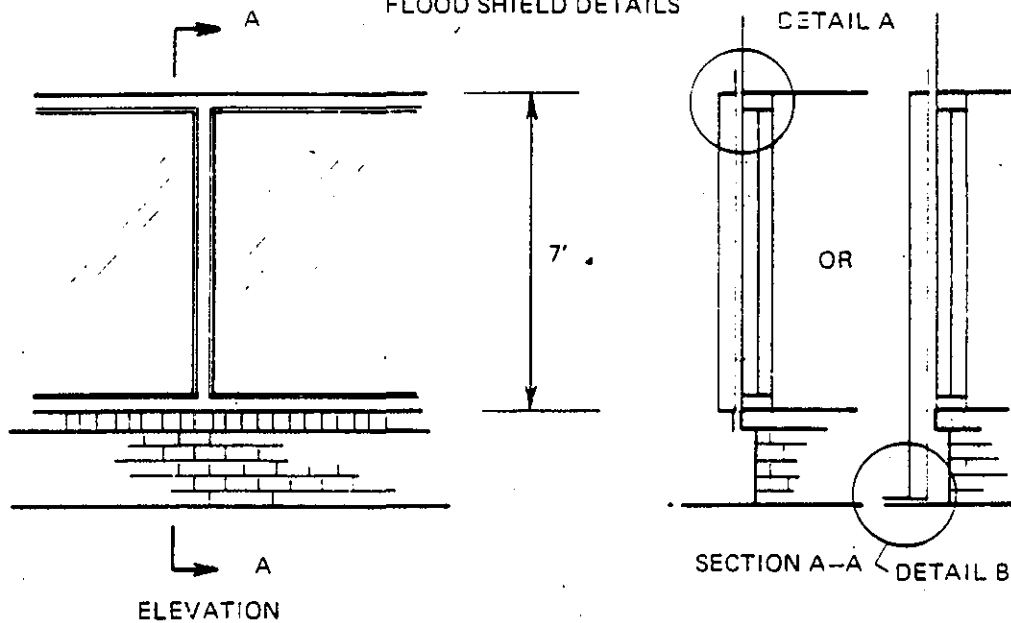
ALL CELLS AROUND OPENINGS IN HOLLOW MASONRY CONSTRUCTION SHOULD BE FILLED WITH CONCRETE. LARGE OPENINGS SHOULD HAVE BOND BEAMS, VERTICAL REINFORCEMENT, AND METAL FRAMES AROUND OPENING.

MORTAR JOINTS THAT LIE WITHIN FLOOD SHIELD SHOULD BE STRUCK FLUSH WITH THE MASONRY UNITS SO THERE WILL BE A BETTER SEAL.

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WATZON, MA.

TYPICAL DOOR CLOSURE PANEL

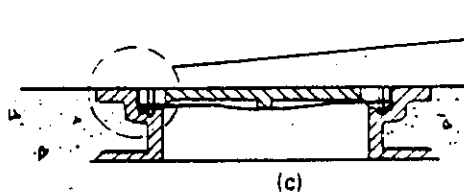
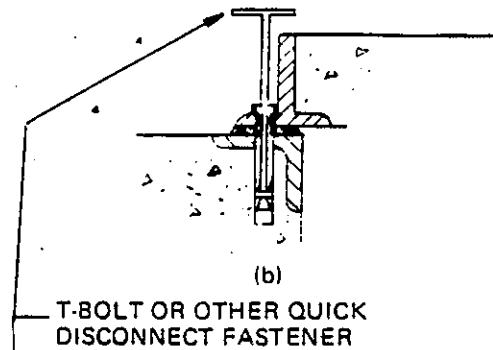
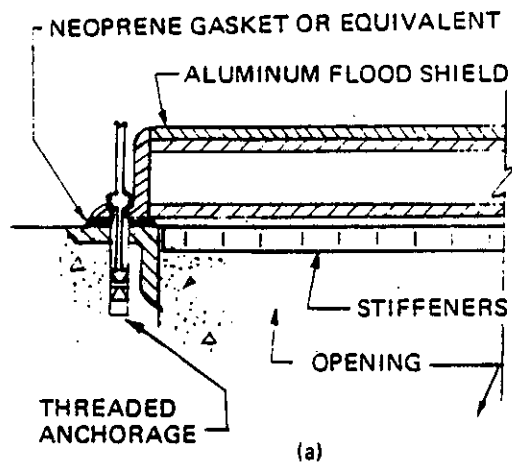
DISPLAY WINDOW FLOOD SHIELD DETAILS



NOTE:
SUPPORT IS ASSUMED AT THIS LOCATION. WHERE SUPPORT IS NOT AVAILABLE,
INCREASE SIZE OR NUMBER OF STIFFENERS AND PROVIDE SUPPORT AT BOTTOM.
MEMBERS ARE SIZED FOR WATER LEVEL AT TOP OF DISPLAY WINDOW.

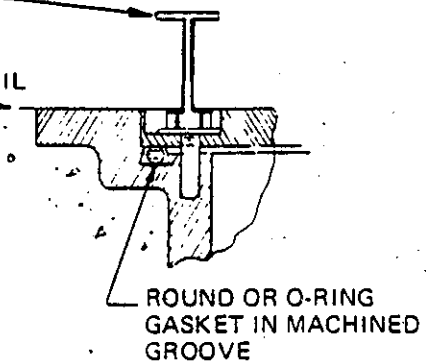
DEPARTMENT OF THE ARMY
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CORPS OF ENGINEERS
WATZON, MA.

TYPICAL DISPLAY WINDOW
CLOSURE PANEL

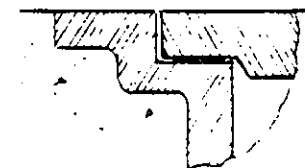
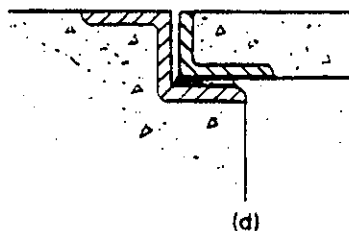


CAST IRON FRAME & COVER
FOR SQUARE, RECTANGULAR
OR CIRCULAR OPENINGS

DETAIL



COVERS FASTENED TO FRAME

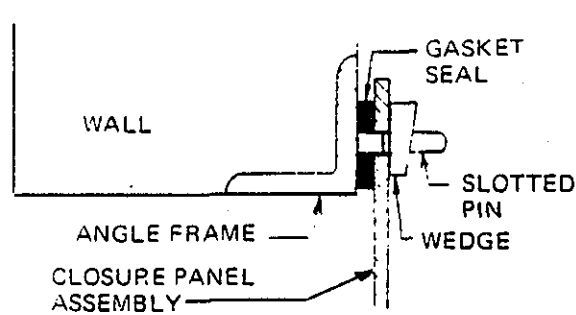


CAST IRON FRAME & COVERS

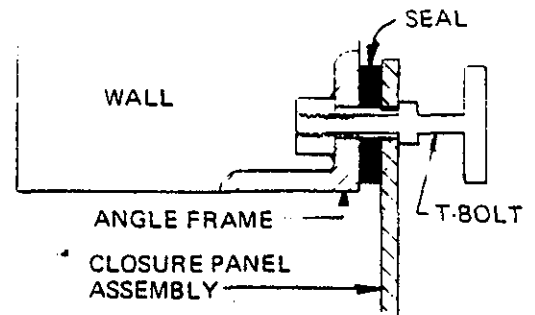
GRAVITY TYPE COVERS
(HELD IN PLACE BY WEIGHT ALONE)

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WALZHAM, MA.

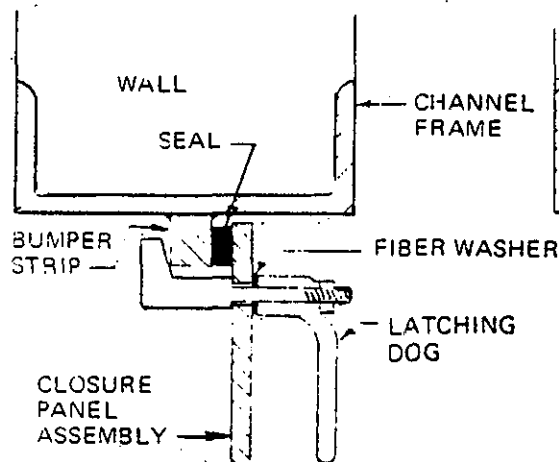
TYPICAL CLOSURE
HORIZONTAL OPENINGS



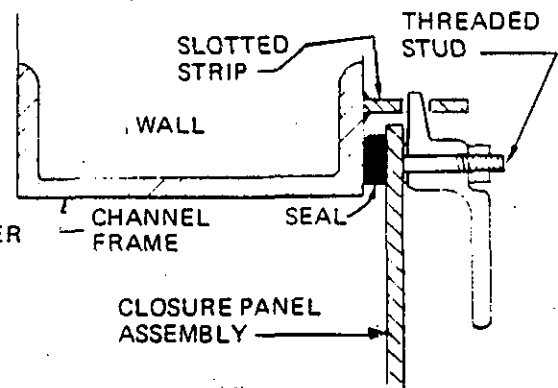
(a)



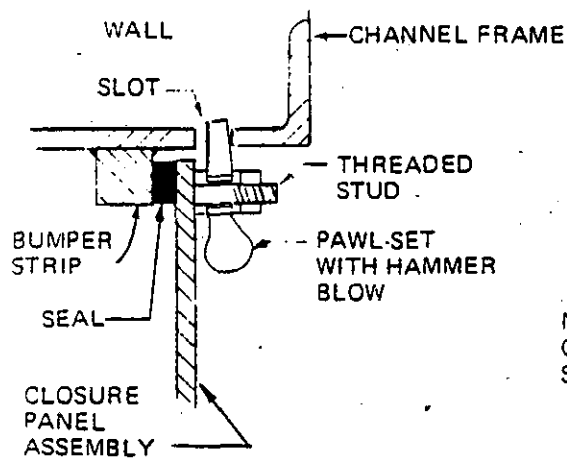
(b)



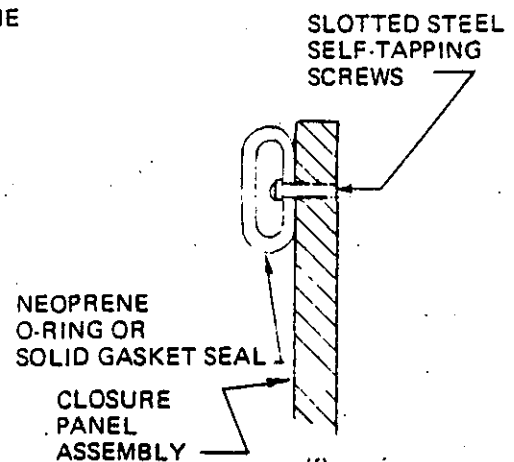
(c)



(d)



(e)



(f)

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NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALZING, MA.

CLOSURE PANEL ASSEMBLY

FASTENING METHODS

annualized over a 100 year period at 8-7/8 percent interest. Nonstructural alternatives were annualized over a 50 year period at 8-7/8 percent interest. The structural and nonstructural local protection projects considered are discussed as follows.

Gardiner

The field survey revealed a total of 56 buildings subject to the 100-year flood elevation of 28.00 feet NGVD. These structures are commercial/industrial buildings with the first floor elevations averaging six (6) to eight (8) feet below the 100-year level with low corner elevations from two (2) to ten (10) feet below the first floor.

Many of these structures have front entrances that are close to street grade, while the rear of the buildings have basement walls that are exposed, providing rear entrances and loading facilities. The floodprone buildings identified are summarized according to usage and structure type as shown below. The Gardiner study area is shown on Plate 29.

<u>Types of Structures</u>	<u>No. of Buildings</u>
Commercial/Storefront (masonry and steel frame)	41
Commercial/Storefront (wood)	<u>15</u>
Total	56

Alternatives considered include approximately 4,000 feet of earthen dike and a nonstructural plan that provides closures for all the of the flood prone buildings. The dike was evaluated at 50 and 100-year levels of protection. The nonstructural plan includes closures for the first floor openings (doors and windows) due to the depth of the flood waters and was evaluated for 100-year protection. Plate 29 shows the approximate extent of the 50 and 100-year flood events. Plate 30 shows the alignment of the proposed dike.

Estimated construction costs and benefits for the protection considered are summarized as follows. Construction costs for the dike were annualized over a 100 year period at 8-7/8 percent interest. Nonstructural construction cost were annualized over a 50 year period at 8-7/8 percent interest. Both of the local protection projects considered for Gardiner could not be economically justified.

Structural Improvement Plan - Gardiner
Dike

	<u>50 Year</u>	<u>100 Year</u>
Annual Benefits	\$356,000	\$395,000
Construction Cost	4,500,000	5,000,000
(Main St. Area)	(166,000)	(194,000)
(SNS Mall Area)	(190,000)	(201,000)
Annual Cost	399,000	444,000
Benefit/Cost Ratio	89 to 1	.89 to 1
Net Benefits	-	-

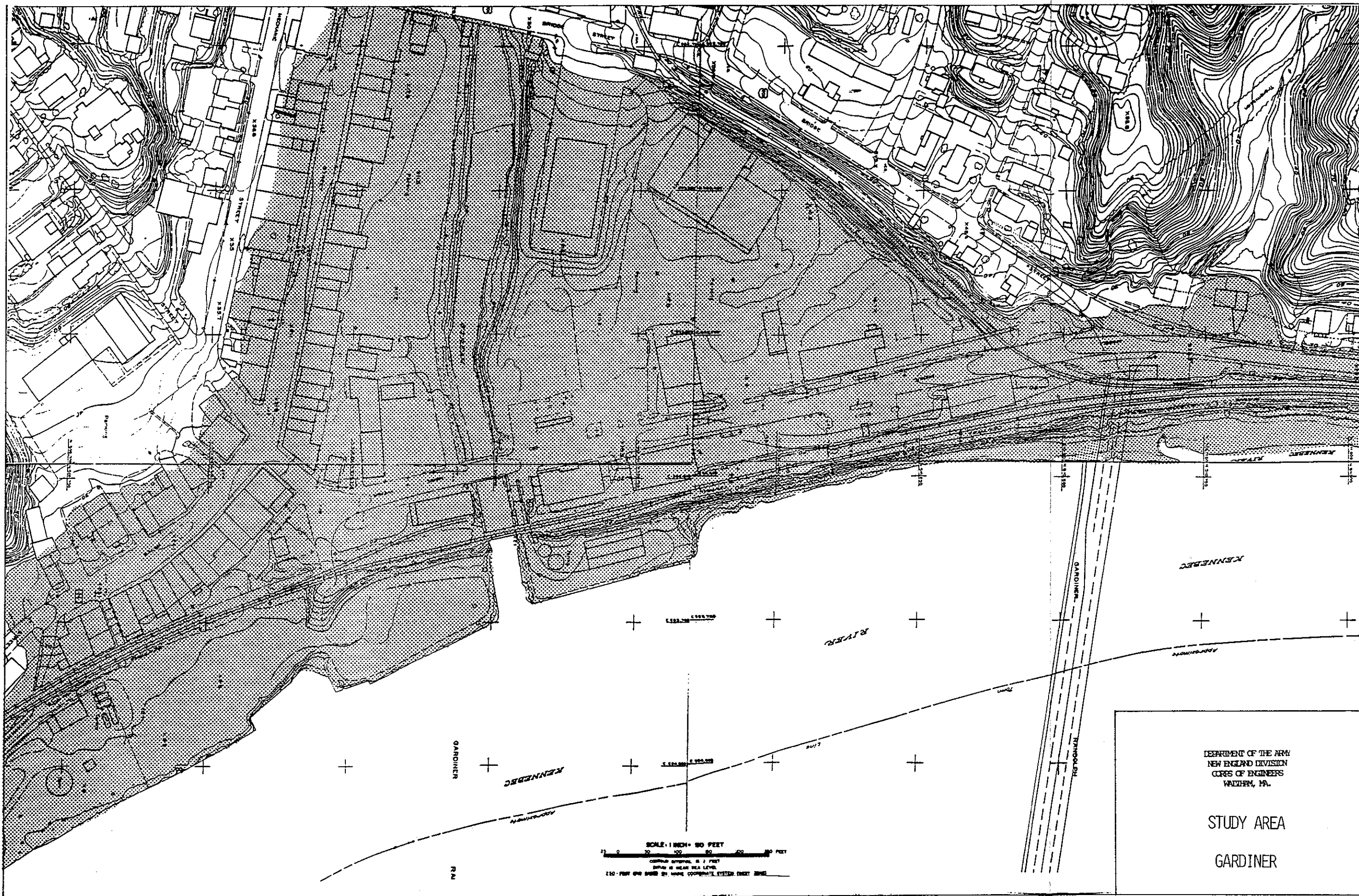
Nonstructural Improvement Plan - Gardiner

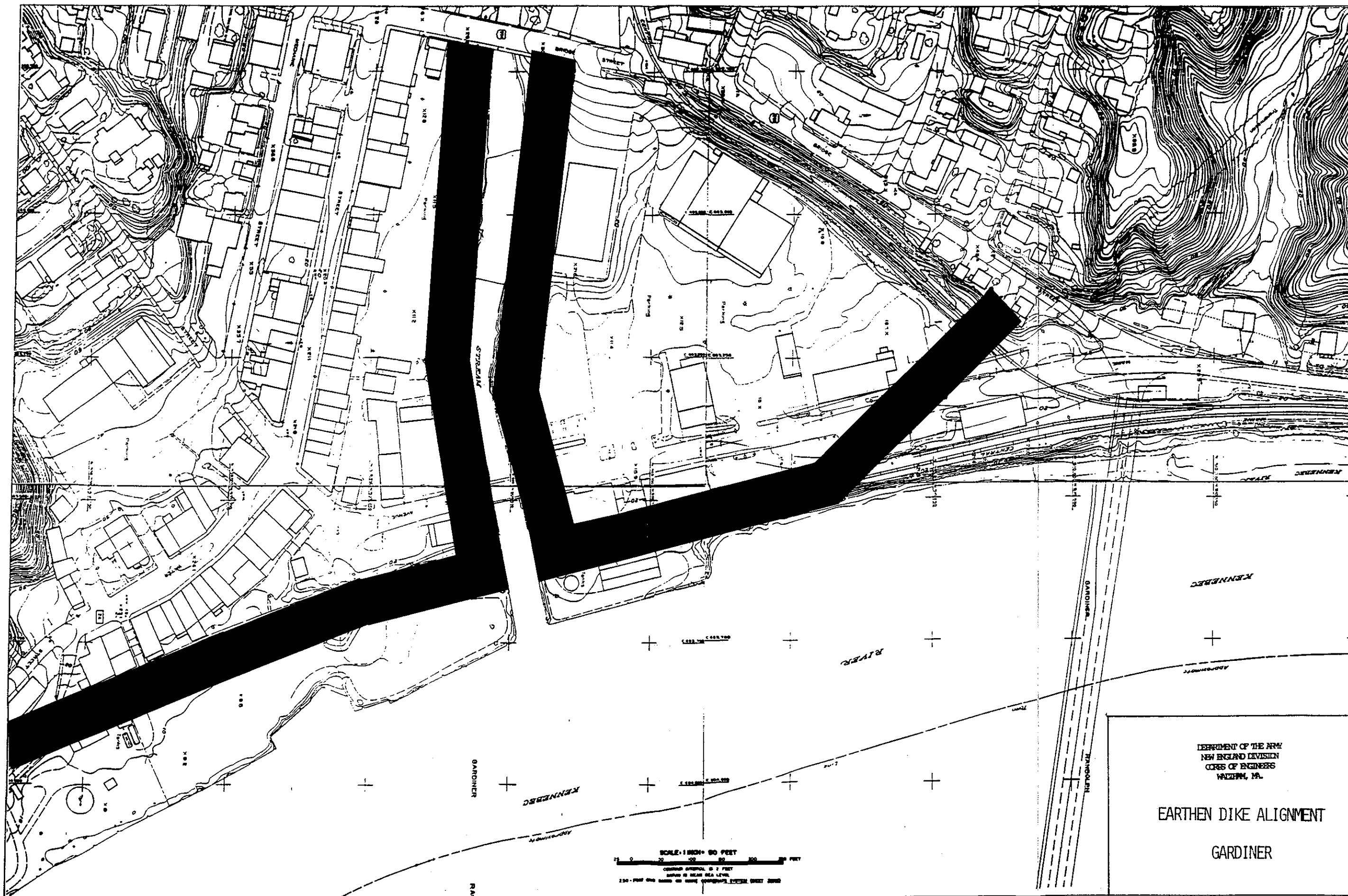
Closures - 56 Buildings

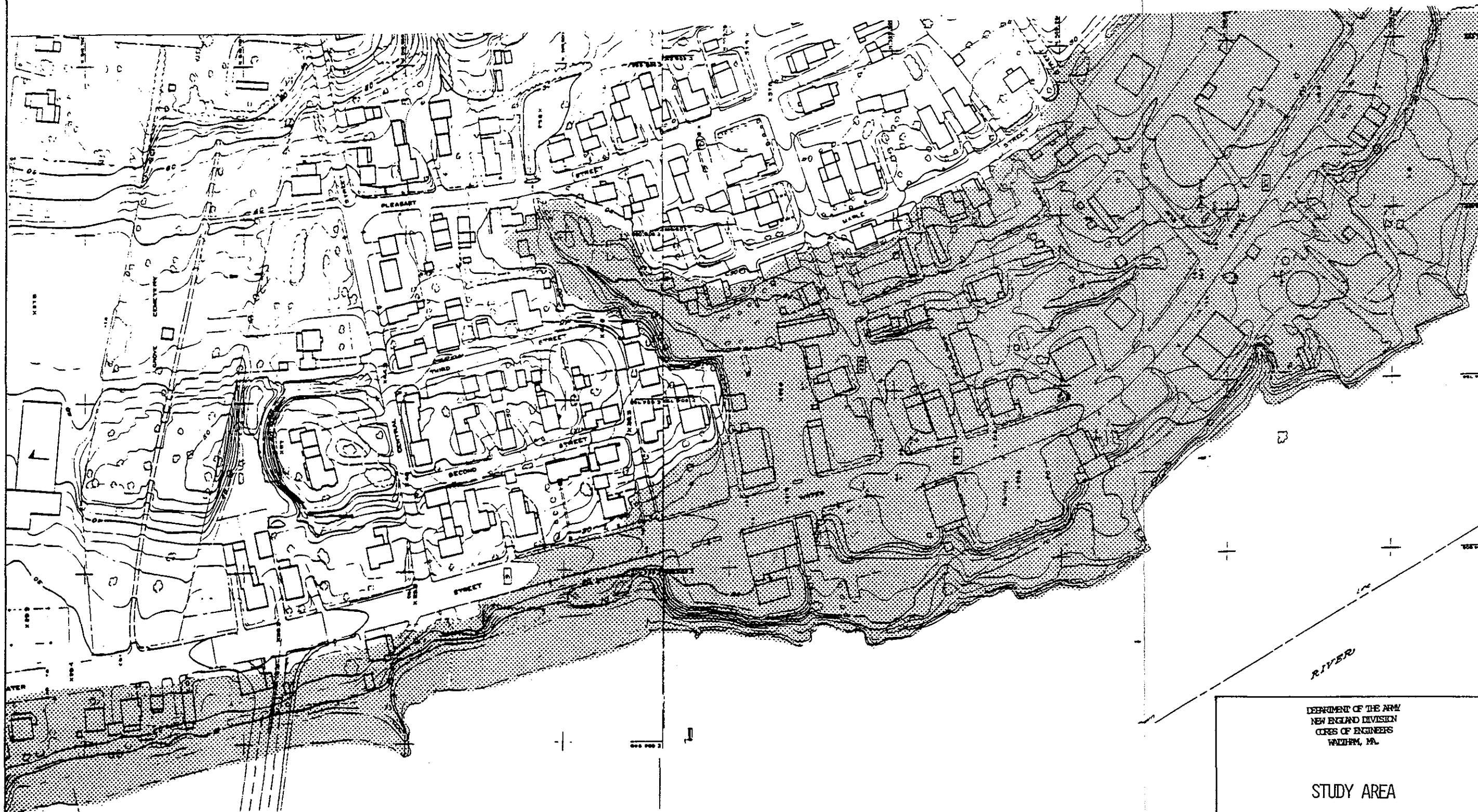
Annual Benefits	\$197,600
Construction Cost	2,383,000
Annual Cost	215,000
Benefit/Cost Ration	.92 to 1
Net Benefits	-

Randolph

The field survey revealed a total of 24 buildings subject to the 100-year flood elevation of 28.00 feet NGVD. The majority of these structures are residential buildings with the first floor elevations averaging four (4) feet below the 100-year level with low corner elevations averaging four (4) feet below the first floor. The commercial structures have an average first floor elevation of eight (8) feet below the 100-level mark and low corner elevations of four (4) feet below the first floor. Plate 31 shows the Randolph study area. The 24 floodprone buildings identified are summarized according to usage and structure type as follows.







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WALTHAM, MA.

STUDY AREA
RANDOLPH

<u>No. of Types of Structures</u>	<u>Buildings</u>
Residential (wood) 1-1/2 stories or less	4
Residential (wood) 2 stories or more	11
Commercial/Storefront (masonry)	6
Commercial/Storefront (wood)	<u>3</u>
Total	24

Structural alternatives to flood protection were not considered because the length required was not considered economically justified. A nonstructural plan providing closures for all the buildings was considered. Closures for first floor openings (doors and windows) were included due to the depth of the flood waters.

Estimated construction costs and benefits for the proposed protection are shown in below. The project cost was annualized over a 50-year period at 8-7/8 percent interest. As shown below the B/C ratio is greater than 1.0 and therefore is considered economically justified.

Nonstructural Improvement Plans - Randolph

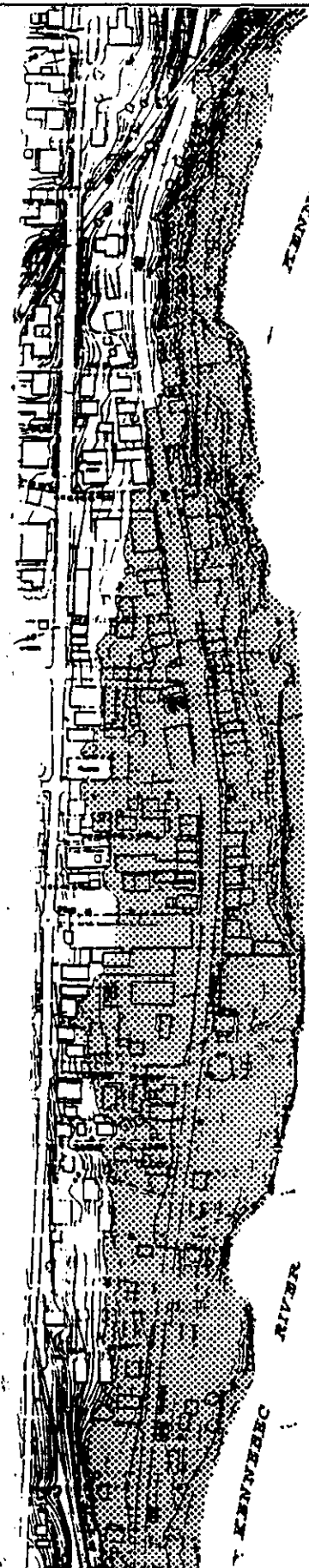
	<u>Raising</u> (4 bldgs)	<u>Closures</u> (24 bldgs)
Annual Benefits	\$20,300	\$71,000
Construction Cost	152,000	625,000
Annual Costs	16,400	56,000
Benefit/Cost Ratio	1.2 to 1	1.27 to 1
Net Benefits	\$ 3,900	\$15,000

Hallowell

The field survey revealed a total of 69 buildings subject to the 100-year flood elevation of 32.00 feet NGVD. The majority of these structures are commercial/industrial buildings with the first floor elevations averaging six (6) to eight (8) feet below the 100-year mark. Approximately half of these commercial buildings have low corner elevations of up to ten (10) feet below the first floor. This indicates that the front entrances are close to the street grade; and at the rear of the building, the basement walls are exposed, providing loading facilities and rear entrances. The remaining commercial buildings have low corners averaging one (1) to two (2) feet below the first floor. The residential structures are primarily single-family homes ranging from small cabins and Capes (1 story to 1-1/2 stories) to larger (2 to 3 stories), more traditional single-family homes. The first floor elevations of these residential structures average four (4) to five (5) feet below the 100-year flood level, with a low corner approximately two (2) to three (3) feet below the first floor. Plate 32 shows the Hallowell study area. The buildings identified as being floodprone are summarized below according to usage and structure type.

<u>Types of Structures</u>	<u>No. of Buildings</u>
Residential (wood) 1-1/2 stories or less	9
Residential (wood) 2 stories or more	10
Residential (masonry)	1
Commercial/Storefront (masonry)	27
Commercial/Storefront (wood)	20
Public Works (masonry)	<u>2</u>
Total	69

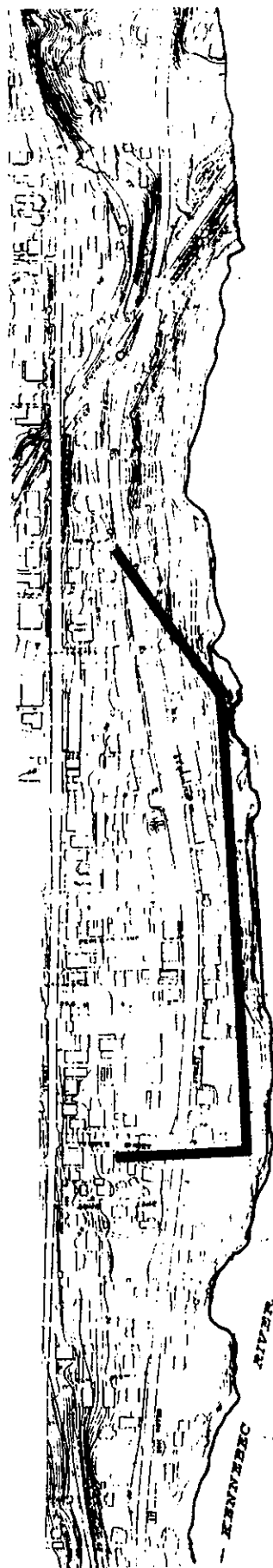
Approximately 3,100 linear feet of floodwall and earthen dike were considered. The proposed structure will provide protection for about 30 commercial (retail) buildings along both sides of Water Street. The majority of these establishments are antique shops, book stores, and restaurants. Plate 33 shows the alignment of the proposed structure. Many of the buildings are outside of the concentrated retail area on Water Street and would not be protected economically by structural means. The floodwalls and dikes were evaluated for 50 and 100-year levels of protection. The nonstructural plan consists of installing closures in the flood prone buildings studied.



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WASHDC, DC

STUDY AREA

HALLOWELL



DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WORCESTER, MA.

WALL/DIKE ALIGNMENT

HALLOWELL

Estimated construction costs and benefits are shown as follows. The structural plan investigated could not be economically justified, however, the nonstructural plan appears economically feasible.

Structural Improvements Plans - Hallowell

	<u>50 Year</u>	<u>Dikes</u> <u>100 Year</u>	<u>Walls</u> <u>50 year</u>	<u>100 Year</u>
Annual Benefits	\$87,600	\$102,000	\$87,600	\$102,000
Construction Cost	2,876,000	3,600,000	6,041,000	8,400,000
Annual Costs	255,000	319,000	536,000	746,000
Benefit/Cost Ratio	.34 to 1	.32 to 1	.16 to 1	.14 to 1
Net Benefits	-	-	-	-

Nonstructural Improvement Plans - Hallowell

	<u>Raising</u> <u>(9 bldgs)</u>	<u>Closures</u> <u>(69 bldgs)</u>
Annual Benefits	\$9,300	\$256,000
Construction Cost	410,000	2,821,000
Annual Costs	36,900	254,000
Benefit/Cost Ratio	.25 to 1	1.01 to 1
Net Benefits	-	2,000

Augusta

The field survey revealed a total of 24 buildings subject to the 100-year flood elevation of 37.00 feet NGVD. Half of these buildings are large, multi-family residences consisting of duplexes, three-deckers and apartment buildings. The commercial buildings also include residences on the floors above the storefronts. The majority of the structures investigated in this community have first floor elevations seven to ten feet below the 100-year flood level. Plate 34 shows the Augusta study area. The floodprone buildings identified are summarized as follows according to usage and structure type.

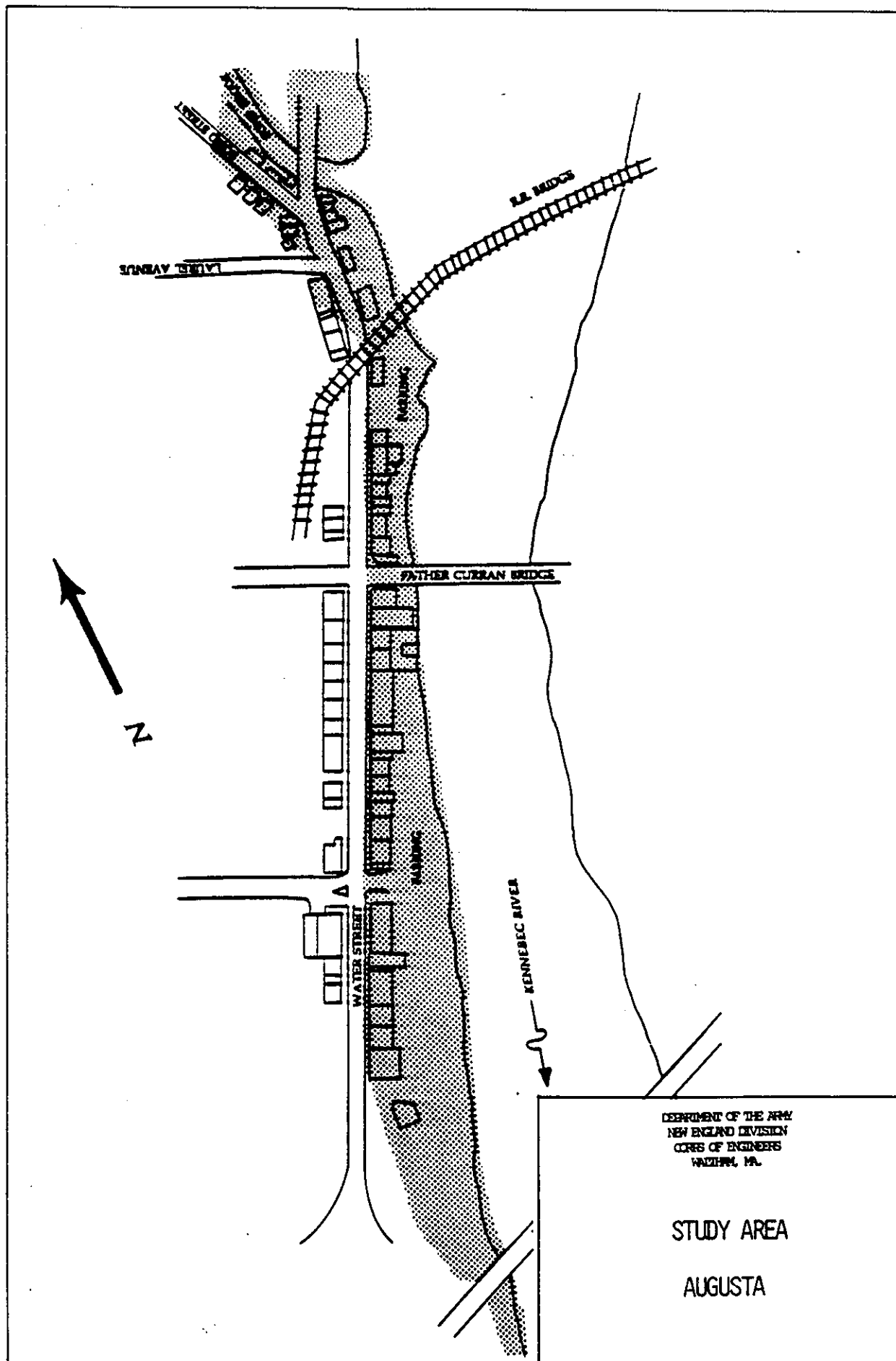
<u>Types of Structures</u>	<u>No. of Buildings</u>
Residential (wood) 2 stories or more	11
Residential (masonry)	3
Commercial/Storefront (masonry)	2
Commercial/Storefront (wood)	4
Public Works (masonry and steel frame)	<u>4</u>
Total	24

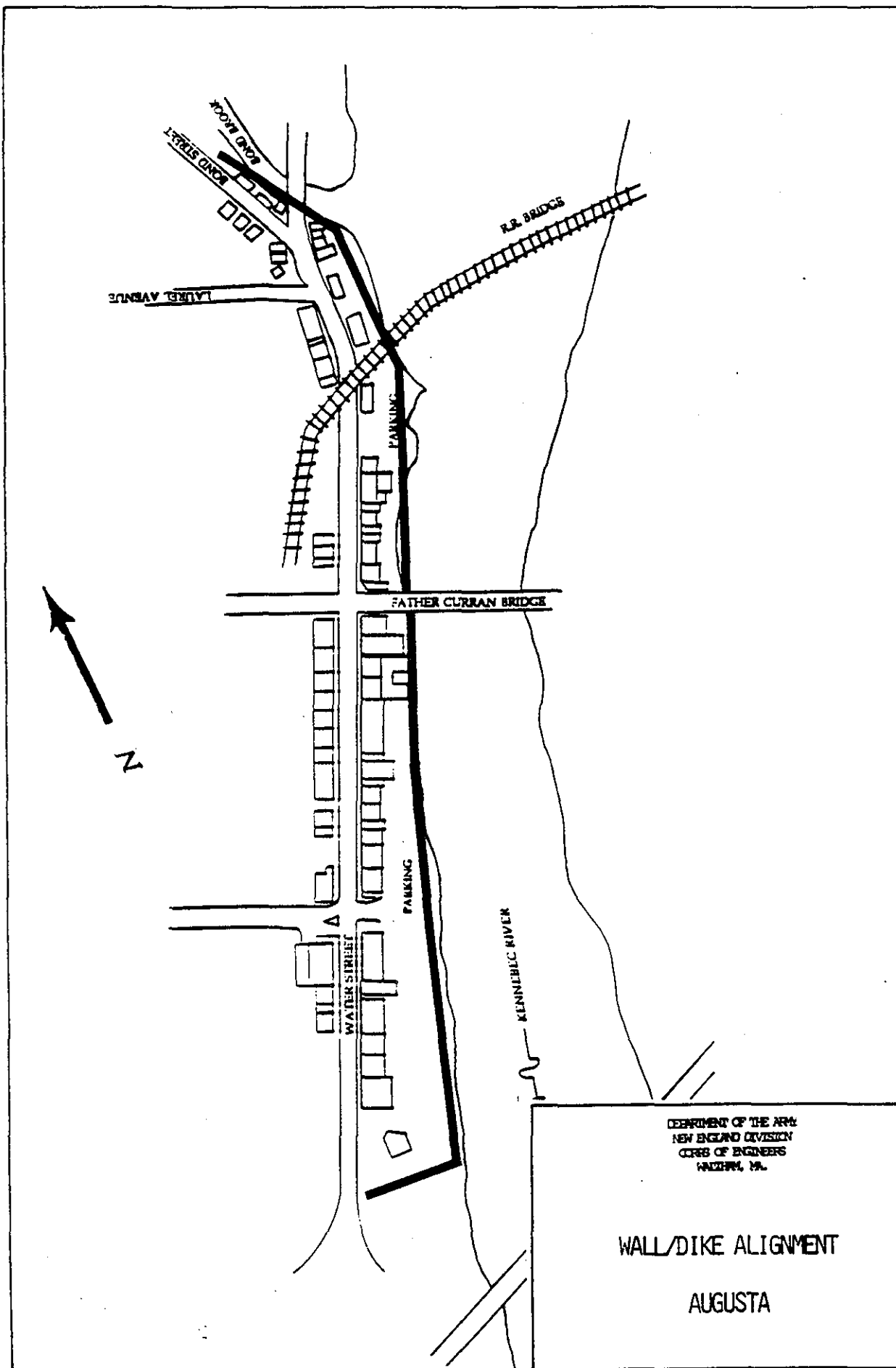
Structural plans for Augusta include dikes and walls both approximately 3,500 feet in length to protect the downtown commercial and residential area along Water Street from Bond Brook to the Memorial Bridge. Plate 35 shows the alignment of the proposed structure. The floodwalls and dikes were evaluated for 50 and 100-year levels of protection. A nonstructural plan was formulated which involves the installation of closures in the 24 flood prone buildings identified. Nonstructural plans were evaluated for 100-year level of protection. Closures for first floor openings (doors and Windows) were included due to the depth of the flood water.

Estimated construction costs and benefits for the projects considered are shown as follows. The structural alternatives could not be economically justified, however nonstructural floodproofing of the 24 buildings did appear economically feasible.

Improvement Plans - Augusta

	<u>Dikes</u>		<u>Walls</u>	
	<u>50 yr</u>	<u>100 yr</u>	<u>50 yr</u>	<u>100 yr</u>
Annual Benefits	\$152,000	\$173,300	\$152,000	\$173,300
Annual Cost	4,024,000	4,800,000	9,266,000	12,100,000
Annual Costs	357,000	426,000	822,000	1,074,000
Benefit/Cost Ratio	0.43	0.41	0.18	0.16
Net Benefits	-	-	-	-





Nonstructural Improvement Plans - Augusta

Closures - 24 Buildings

Annual Benefits	\$155,000
Construction Cost	922,000
Annual Costs	83,000
Benefit/Cost Ratio	1.87
Net Benefits	\$72,000

Waterville

The field survey revealed a total of 28 buildings subject to the 100-year flood elevation of 66.00 feet NGVD. The majority of these structures are residential buildings which are a combination of single and multi-family dwellings consisting of two or more stories. In approximately half of these structures, the first floor elevation is four feet below the 100-year flood elevation, with the low corner two to three feet below the first floor. For these residential units, the first floor windows would require floodproofing. The remaining residential units have first floor elevations ranging from zero (0) feet to two (2) feet below the 100-year level, with low corner elevations one (1) to two (2) feet below the first floor. These buildings would require floodproofing for entrances and any openings below the first floor. The first floor elevations of the few commercial and industrial structures are approximately five (5) feet below the 100-year flood elevation with low corner elevations between two (2) to three (3) feet below the first floor. Plate 36 shows the Waterville study area. The 28 floodprone buildings identified are summarized below according to usage and structure type.

<u>Types of Structures</u>	<u>No. of Buildings</u>
Residential (wood) 2 stories or more	20
Commercial/Industrial (masonry)	5
Commercial/Storefront (wood)	<u>3</u>
Total	28

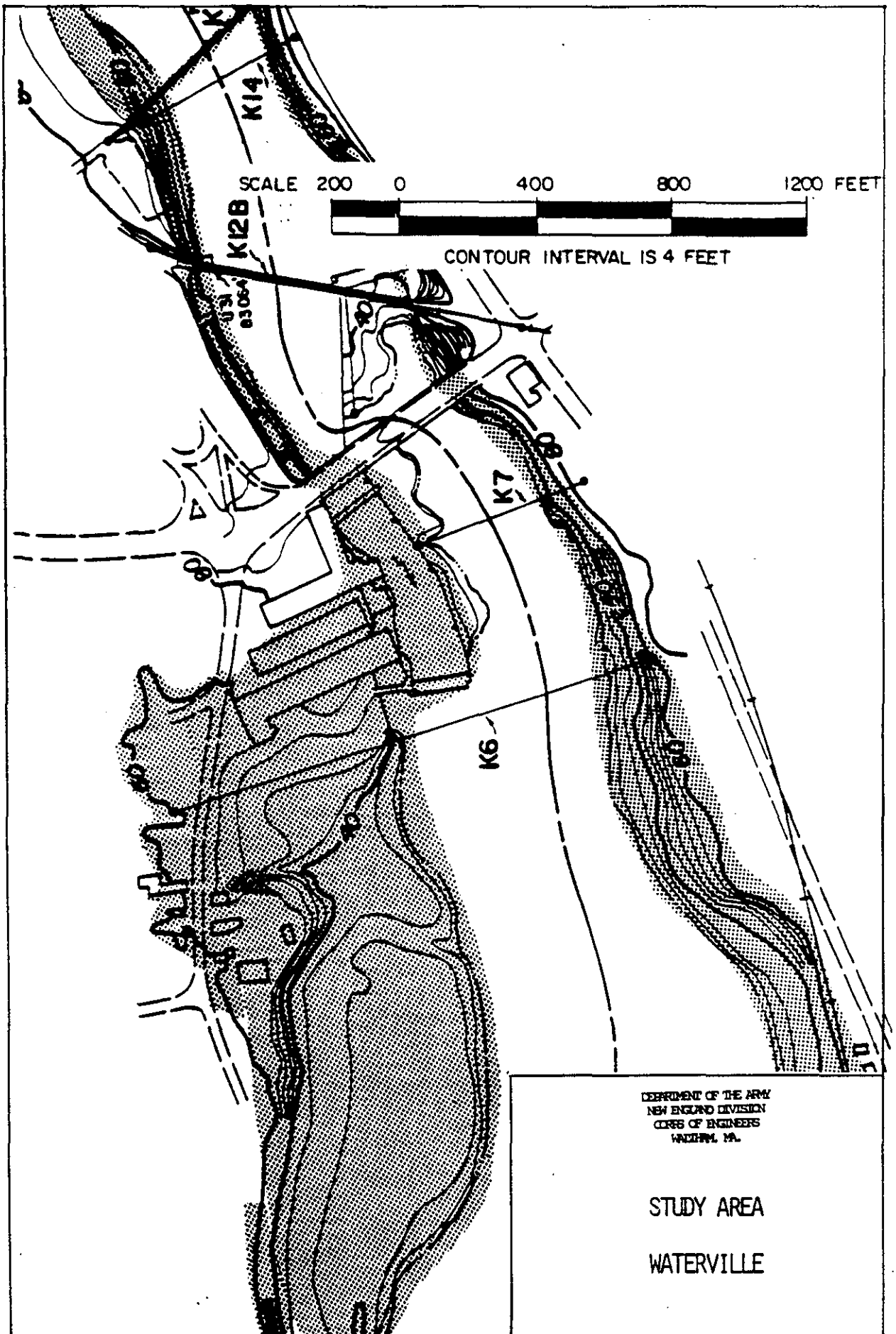
Approximately 1,400 feet of earthen dike was considered for a structural protection plan. Plate 37 shows the alignment of the proposed dike. A nonstructural plan which provides closures for all the buildings studied was also investigated. Estimated construction costs and benefits are shown as follows. Economic justification could not be found in either of the alternatives considered.

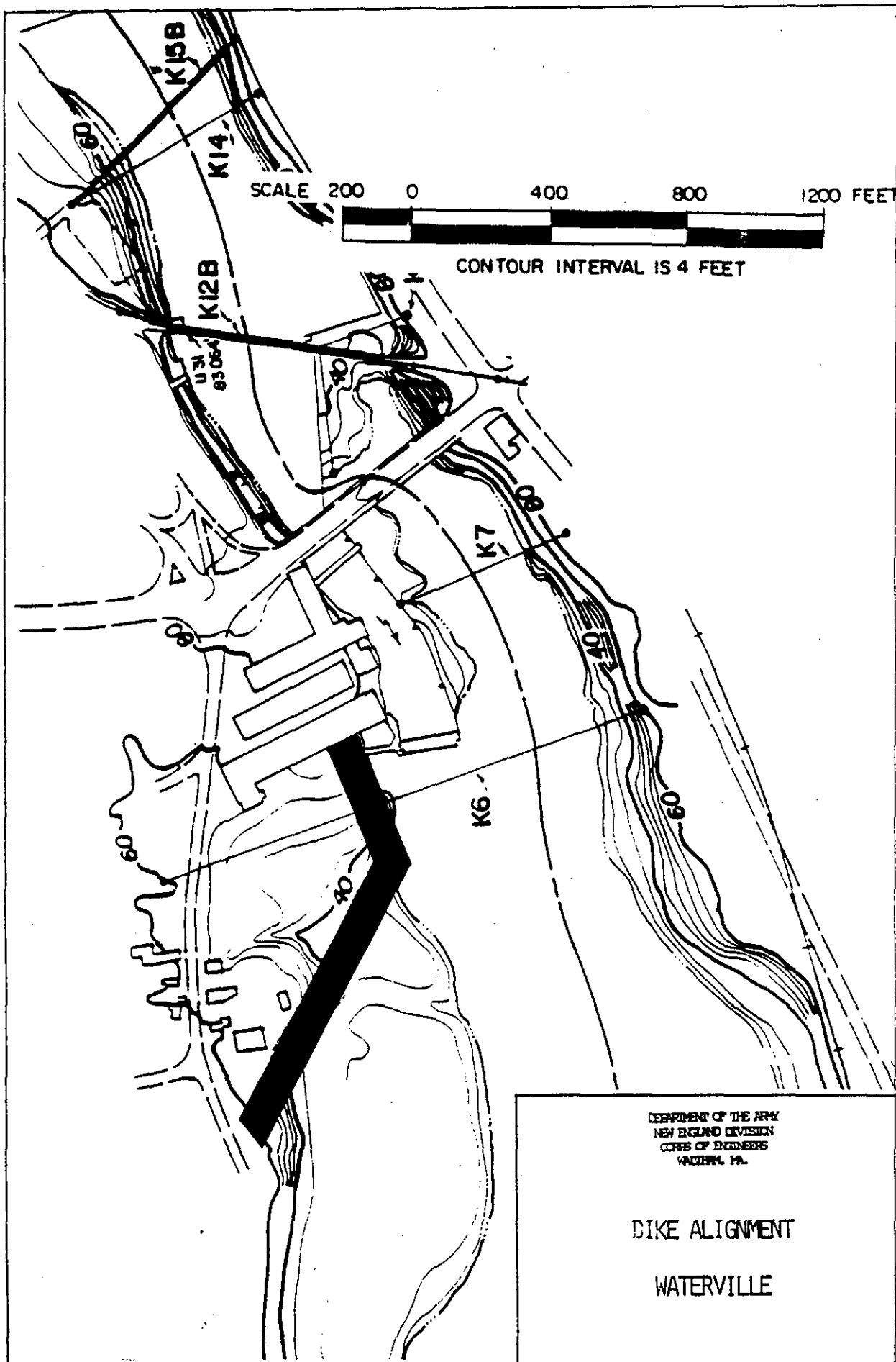
Improvement Plans - Waterville

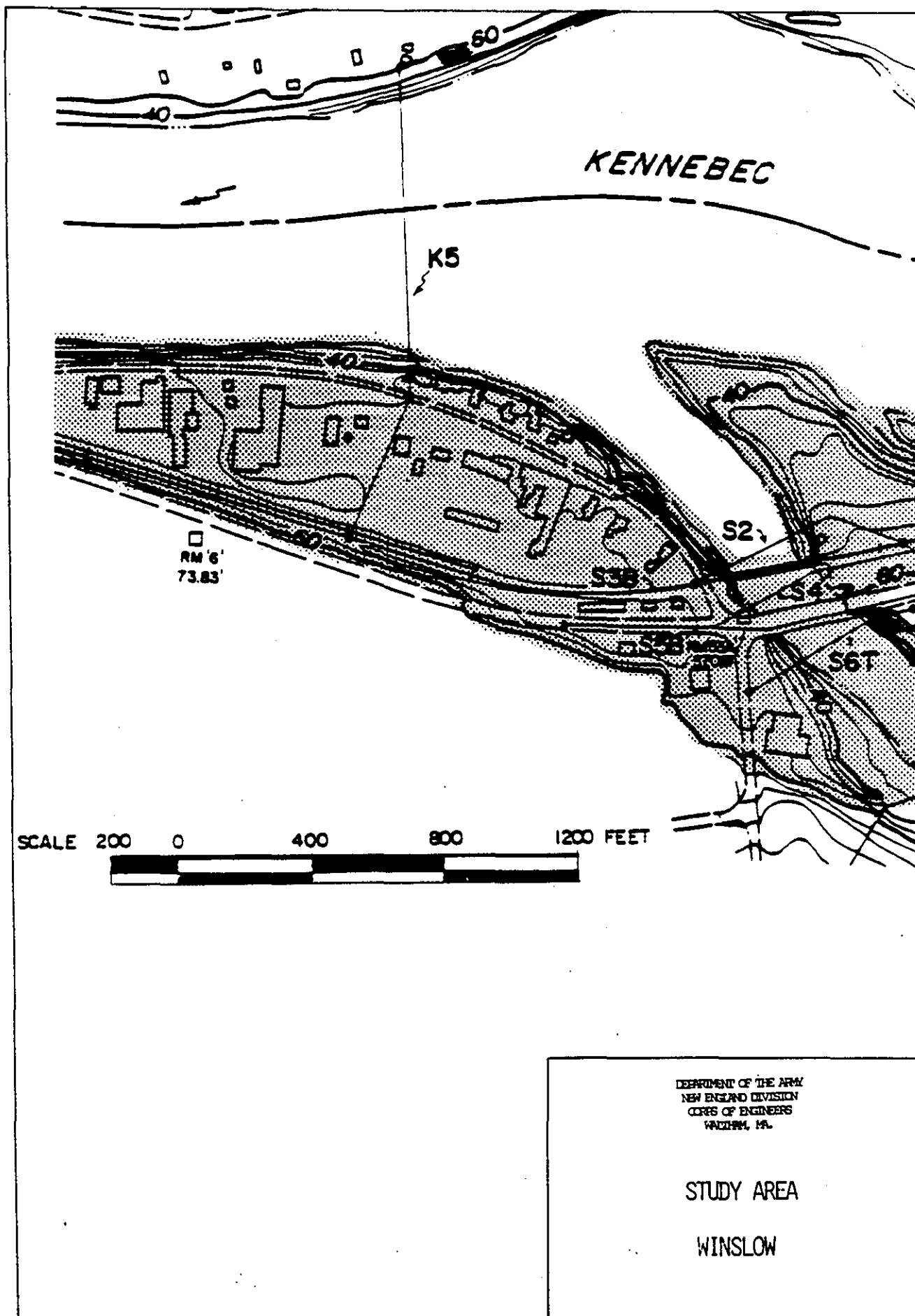
	<u>Structural</u> (dike)		<u>Nonstructural</u> (Closures)
	<u>50 Year</u>	<u>100 Year</u>	
Annual Benefits	\$31,400	\$54,300	\$12,000
Construction Cos	1,228,000	1,600,000	892,800
Annual Costs	109,000	142,000	80,000
Benefit/Cost Ratio	.28 to 1	.38 to 1	.15 to 1
Net Benefits	-	-	-

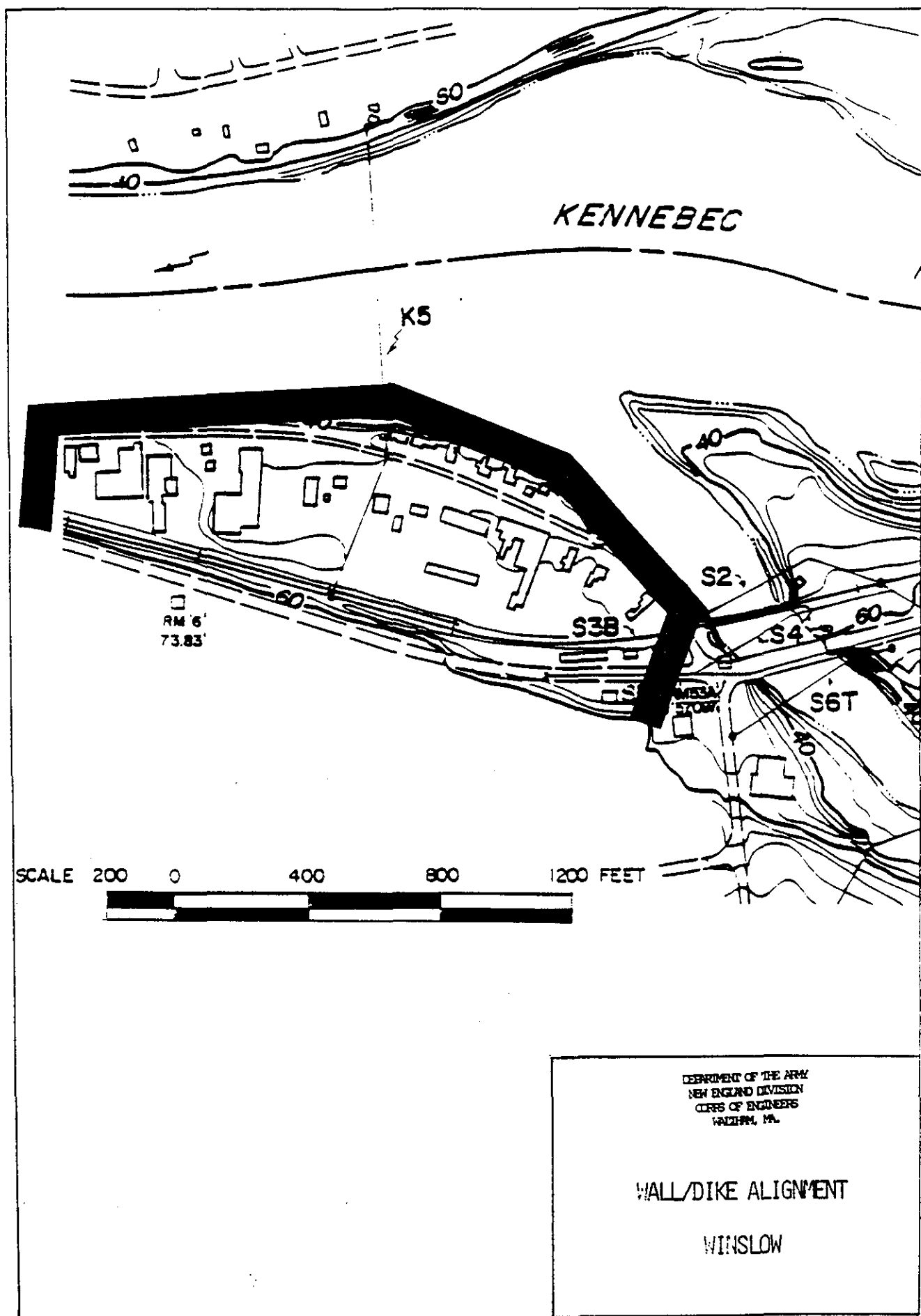
Winslow

The field survey revealed a total of 21 buildings subject to the 100-year flood elevation of 62.00 feet NGVD. The majority of these structures are commercial/industrial buildings with the first floor elevations averaging nine (9) feet below the 100-year level, and low corner elevations averaging one to two feet below the first floor elevations. The residential structures are primarily average size single-family homes with first floor elevations from three feet to eight feet below the 100-year level. Low corners are generally two feet below the first floor. Plate 38 shows the Winslow study area. The 21 floodprone buildings identified are summarized below according to usage and structure type.









<u>Types of Structures</u>	<u>No. of Buildings</u>
Residential (wood) 2 stories or more	4
Commercial/Storefront (masonry)	7
Commercial/Storefront (wood)	8
Public Works (masonry)	<u>2</u>
Total	21

Approximately 3,100 linear feet of concrete floodwall and earthen dike were considered as protection for the residential and commercial structures along Lithgow Street. The floodwalls and dikes were evaluated for 50 and 100-year levels of protection. Plate 39 shows the alignment of the proposed protection plan. A nonstructural protection plan providing closures for all floodprone structures was also considered. Nonstructural plans were evaluated for 100-year level of protection. Closures for first floor openings were included due to the depth of the flood water.

Estimated construction costs and benefits for the structural and nonstructural projects considered are shown as follows. Economic justification could not be found in either case.

Structural Improvement Plans - Winslow

	<u>Dikes</u>		<u>Walls</u>	
	<u>50 Year</u>	<u>100 Year</u>	<u>50 Year</u>	<u>100 Year</u>
Annual Benefits	\$73,300	\$104,000	\$73,300	\$104,000
Construction Cost	3,368,000	4,500,000	7,639,000	11,400,000
Annual Costs	299,000	399,000	678,000	1,012,000
Benefit/Cost Ratio	.24 to 1	.26 to 1	.11 to 1	.10 to 1
Net Benefits	-	-	-	-

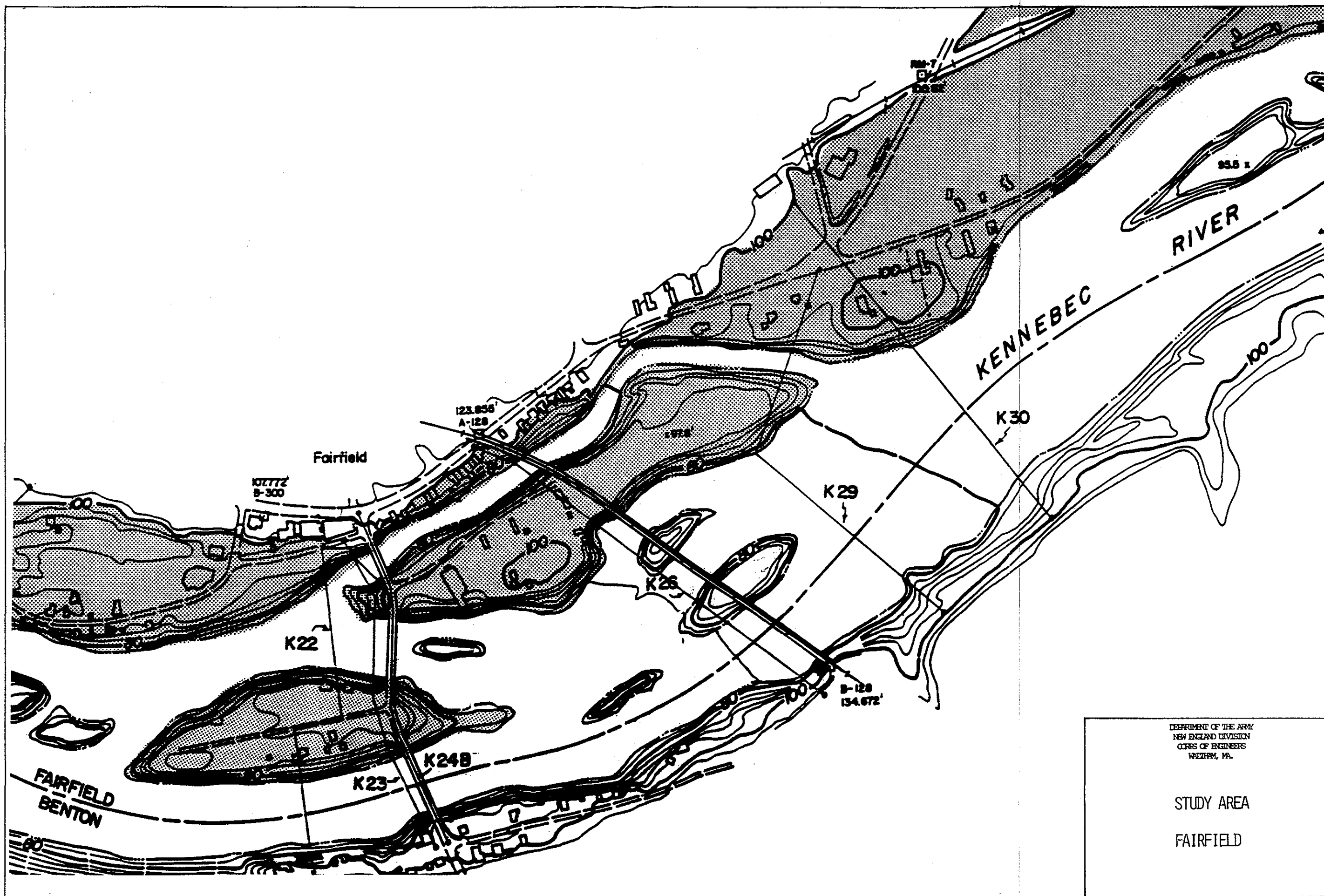
Nonstructural Improvement Plan - Winslow

	<u>Closures</u>
Annual Benefits	\$53,400
Annual Costs	74,000
Benefit/Cost Ratio	.72 to 1
Net Benefits	-

Fairfield

The field survey revealed a total of 65 buildings subject to the 100-year flood elevation of 99.00 feet NGVD. The majority of these structures are residential buildings with the first floor elevations averaging two (2) to three (3) feet below the 100-year level, with a low corner elevation of four (4) feet below the first floor. These residential structures are primarily single-family homes ranging from small cabins, mobile homes (one park with 16 units) and Capes (1 story to 1-1/2 stories) to larger (2 to 3 stories), more traditional single family homes. The commercial, public works and public assembly structures have an average first floor elevation of one (1) foot below the 100-year mark and low corner elevations two (2) feet below the first floor. Plate 40 shows the Fairfield study area. The 65 buildings identified are summarized below according to structure type and usage.

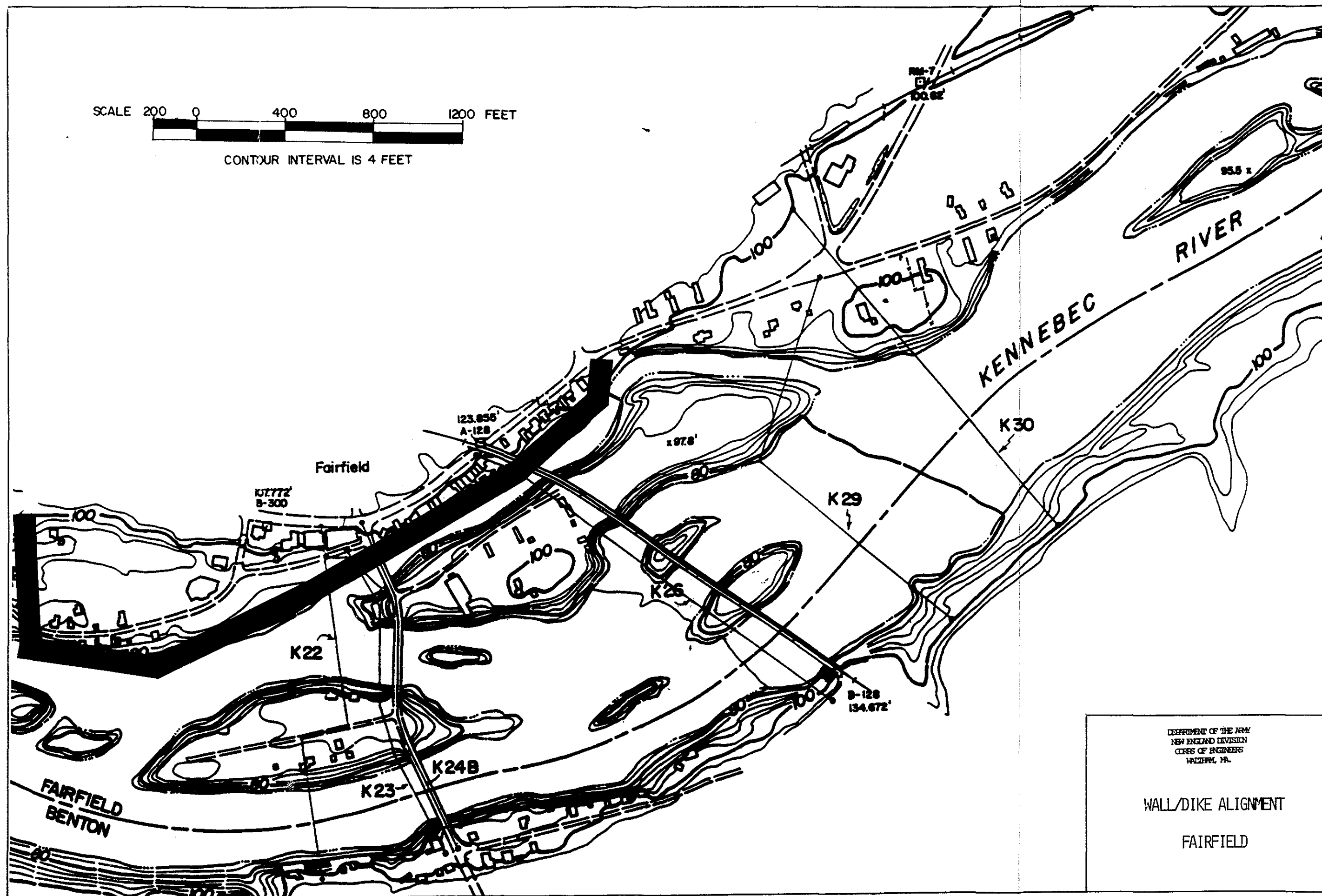
<u>Types of Structures</u>	<u>No. of Buildings</u>
Residential (wood) 1-1/2 stories or less (includes mobile homes)	37
Residential (wood) 2 stories or more	18
Residential (masonry)	1
Commercial/Storefront (masonry)	2
Commercial/Storefront (wood)	2
Public Works and Assembly (masonry)	<u>5</u>
Total	65



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STUDY AREA

FAIRFIELD



Approximately 4,500 feet of dike and floodwall were considered. There are two separate damage centers in Fairfield, The Water Street area and the upper Main Street area. Recurring losses are nearly equal for the two separate areas and become significant at events approaching the 100-year event. Structural protection was investigated for the Water Street area. Plate 41 shows the proposed alignment. The cost of structural protection for the upper Main Street area would be comparable to the Water Street area. A nonstructural alternative involving raising structures and providing closures was also investigated. Only a small number of the buildings investigated would require closures for first floor openings.

Estimated construction costs and benefits for the projects considered are shown as follows. No economic justification could be found for the alternatives considered.

Structural Improvement Plans - Fairfield

	<u>Dikes</u>		<u>Walls</u>	
	<u>50 yr.</u>	<u>100 yr.</u>	<u>50 yr.</u>	<u>100 yr.</u>
Annual Benefits	\$12,100	\$23,400	\$12,100	\$23,400
Construction Cost	3,992,000	5,530,000	6,284,000	9,485,000
Annual Costs	354,000	491,000	558,000	842,000
Benefit/Cost Ratio	.03 to 1	.05 to 1	.02 to 1	.03 to 1
Net Benefits	-	-	-	-

Nonstructural Improvement Plans - Fairfield

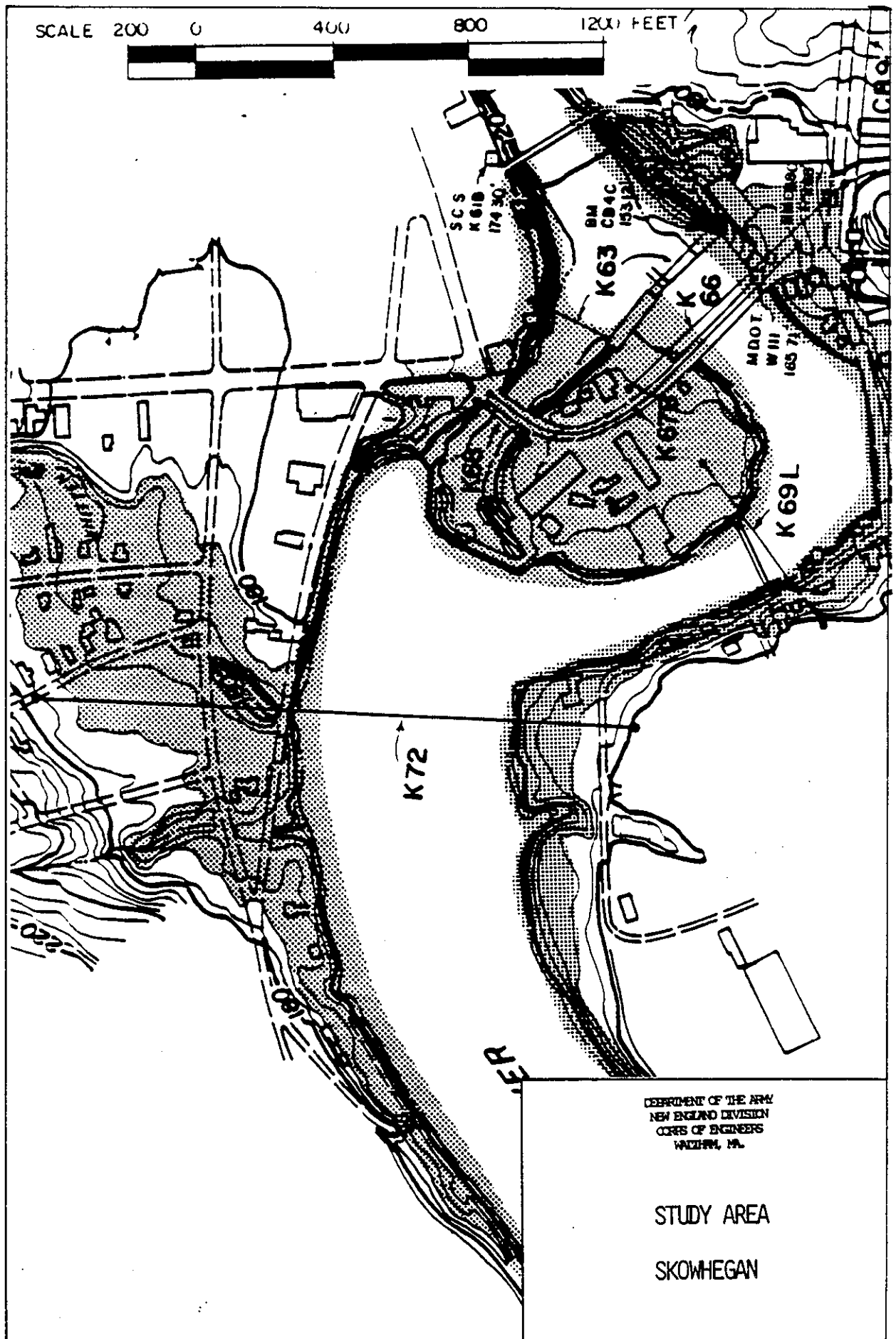
	<u>Raising</u> (37 bldgs)	<u>Closures</u> (65 bldgs)
Annual Benefits	\$9,800	\$17,800
Construction Cost	1,406,000	775,000
Annual Costs	151,900	70,000
Benefit/Cost Ratio	.06 to 1	.26 to 1
Net Benefits	-	-

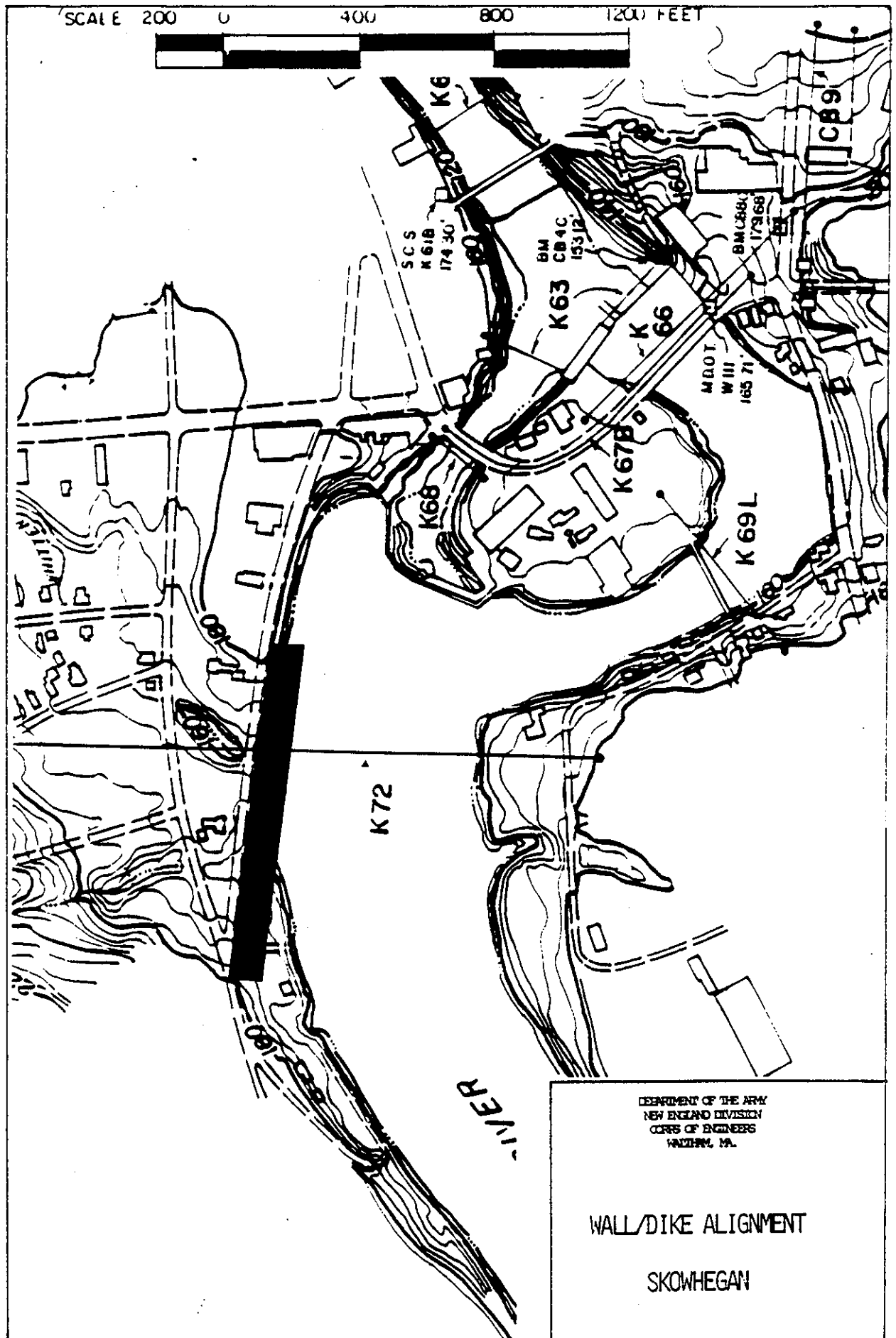
Skowhegan

The field survey revealed a total of 54 buildings subject to the 100-year flood elevation of 173.00 feet NGVD. The commercial- industrial buildings have first floor elevations averaging three (3) feet below the 100-year level with low corner elevations of three (3) to fifteen (15) feet below the first floor. The residential structures are primarily single-family homes with first floor elevations of two (2) feet below the 100-year level and low corners of two (2) to six (6) feet below the first floor. Plate 42 shows the Skowhegan study area. The buildings identified as floodprone are summarized below according to usage and structure type.

<u>Types of Structures</u>	<u>No. of Buildings</u>
Residential (wood & one masonry) 1-1/2 stories or less	9
Residential (wood) 2 stories or more	23
Commercial/Storefront (masonry)	16
Commercial/Storefront (wood)	3
Public Works (masonry)	<u>3</u>
Total	54

Structural plans for Skowhegan involved dikes and walls both approximately 1,400 feet in length, to protect residential structures along Elm and Pleasant Streets. Plate 43 shows the alignment of the proposed protection plans. Neither the 50 or 100-year protection plans could be economically justified. Nonstructural plans investigated raising the first floor elevations of 9 residences and providing closures for the remainder of the flood prone structures. The nonstructural plan could not be economically justified either. Estimated construction costs and benefits for the proposed projects are shown as follows.





Nonstructural Improvement Plans - Skowhegan

	<u>Raising</u> (9 bldgs)	<u>Closures</u> (21 bldgs)
Annual Benefits	\$2,600	\$17,200
Construction Cost	410,000	1,254,000
Annual Costs	36,900	113,000
Benefit/Cost Ratio	.07 to 1	.15 to 1
Net Benefits	-	-

Structural Improvement Plan - Skowhegan

	<u>Dikes</u>	<u>Walls</u>		
	<u>50 yr.</u>	<u>100 yr.</u>	<u>50 yr.</u>	<u>100 yr.</u>
Annual Benefits	\$100	\$900	\$100	\$900
Construction Cost	653,000	1,053,000	894,000	1,972,000
Annual Cost	50,000	93,000	79,000	175,000
Benefit/Cost Ratio	0.0	0.0	0.0	0.0
Net Benefits	-	-	-	-

Madison

The field survey revealed a total of 5 buildings subject to the 100-year flood elevation of 260.00 feet NGVD. These structures are commercial/industrial buildings with the first floor elevations ranging from four (4) to eleven (11) feet below the 100-year level. The low corner elevations range from grade to twenty (20) feet below the first floor. Several buildings foundation's are also located directly on the banks of the river. Plate 44 shows the Madison study area. A summary of the floodprone structures identified is shown below.

<u>Types of Structures</u>	<u>No. of Buildings</u>
Commercial/Industrial (masonry)	3
Commercial/Storefront (wood)	<u>2</u>
Total	5

The damage area in Madison currently has a private system of walls and dikes providing 50-year protection. The structural improvement plan would increase the height of protection to the 100 year level plus 3 feet of freeboard. Plate 45 shows the alignment of existing and proposed structure. The nonstructural plan would provide closures for the five buildings identified as being floodprone. A summary of the estimated costs and benefits for the projects considered are shown as follows. Only the nonstructural plan could be economically justified.

Improvement Plans - Madison

	<u>Structural</u> (Dike and Wall)	<u>Nonstructural</u> (Closures)
Annual Benefits	\$42,000	\$43,000
Construction Cost	760,000	185,000
Annual Costs	67,000	17,000
Benefit/Cost Ratio	.63 to 1	2.5 to 1
Net Benefits	-	\$26,000

Anson

The field survey revealed a total of 9 buildings subject to the 100-year flood elevation of 260.00 feet NGVD. The commercial-industrial buildings have first floor elevations averaging four (4) feet below the 100-year level with low corners of one (1) to (2) feet below the first floor. The residential structures are primarily single-family homes with first floor elevations of one (1) foot below the 100-year flood level, with a low corner approximately two to three feet below the first floor. Plate 46 shows the Anson study area. The floodprone structures identified are summarized below according to usage and structure type.

<u>Types of Structures</u>	<u>No. of Buildings</u>
Residential (wood) 2 stories or more	2
Commercial/Storefront (masonry)	3
Commercial/Storefront (wood)	4
Total	9

Annual losses of \$5,000 precluded the formulation of structural plans due to the slight chance of economic justification. Benefits were estimated for a nonstructural plan which would provide closures for first floor door openings and openings below the first floor. The plan could not be economically justified. A summary of the estimated construction costs and benefits are shown as follows.

<u>Nonstructural Plan Closures</u>	
Annual Benefits	\$1,000
Construction Cost	312,000
Annual Cost	28,000
Benefit/Cost Ratio	.04 to 1
Net Benefits	-

Farmington

The field survey revealed a total of 32 buildings subject to the 100-year flood elevation of 360.00 feet NGVD. The commercial-industrial buildings have an average first floor elevations of six (6) feet below the 100-year level with low corner elevations averaging two (2) feet below the first floor. The residential structures are primarily single-family homes with first floor elevations of two (2) to four (4) feet below the 100-year flood level, with a low corner

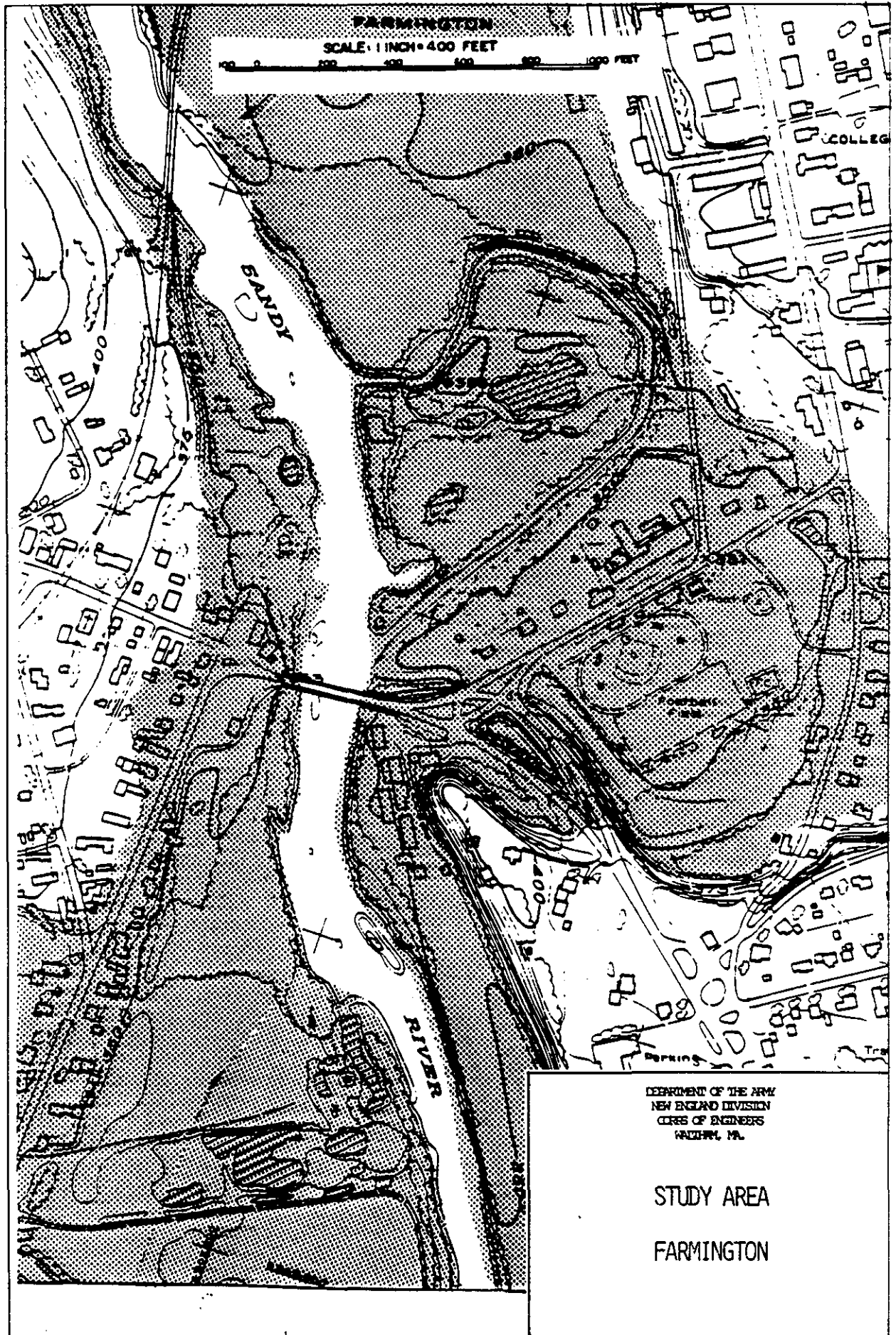
approximately two to three feet below the first floor. Plate 46 shows the Farmington study area. The floodprone structures identified are summarized below according to their usage and structure type.

<u>Types of Structures</u>	<u>No. of Buildings</u>
Residential (wood) 1-1/2 stories or less	5
Residential (wood) 2 stories or more	14
Commercial/Storefront (masonry)	4
Commercial/Storefront (wood)	<u>9</u>
Total	32

The structural plan of improvement investigated includes earthen dikes and walls approximately 1,600 feet in length along Water Street. The plan would provide protection for approximately 15 commercial properties. Plate 47 shows the proposed alignment. Nonstructural plans consisted of providing closures for all 32 floodprone structures identified. Closures for first floor doors and openings were included due to the depth of flood waters. Estimated construction costs and benefits are shown as follows. Only the nonstructural alternative could be economically justified.

Structural Improvement Plans - Farmington

	<u>Dikes</u>		<u>Walls</u>	
	<u>50 Year</u>	<u>100 Year</u>	<u>50 Year</u>	<u>100 Year</u>
Annual Benefits	\$43,000	\$49,300	\$43,000	\$49,300
Construction Cost	703,000	965,000	1,127,000	1,595,000
Annual Costs	62,000	86,000	100,000	142,000
Benefit/Cost Ratio	.69 to 1	.57 to 1	.43 to 1	.34 to 1
Net Benefits	-	-	-	-



Nonstructural Improvement Plans - Farmington

	<u>Raising</u> (5 bldgs)	<u>Closures</u> (32 bldgs)
Annual Benefits	\$7,700	\$74,600
Construction Cost	190,000	752,000
Annual Costs	20,500	68,000
Benefit/Cost Ratio	.38 to 1	1.1 to 1
Net Benefits	-	6,600

Pittsfield

The field survey revealed a total of 37 buildings subject to the 100-year flood elevations of 196.5 feet NGVD and 210.0 feet NGVD. The majority of the structures are located in the 210.0 feet NGVD flood zone and they consist primarily of single family residential buildings. These buildings have first floor elevations averaging zero (0) to two (2) feet below the 100-year level with low corner elevations three (3) to five (5) feet below the first floor. The commercial structures are located in the 196.5 flood area; the first floor elevations are above the flood level, but low corner elevations are two (2) feet below the 100-year mark. The floodprone structures identified are summarized below according to usage and structure type. Plate 48 shows the Pittsfield study area.

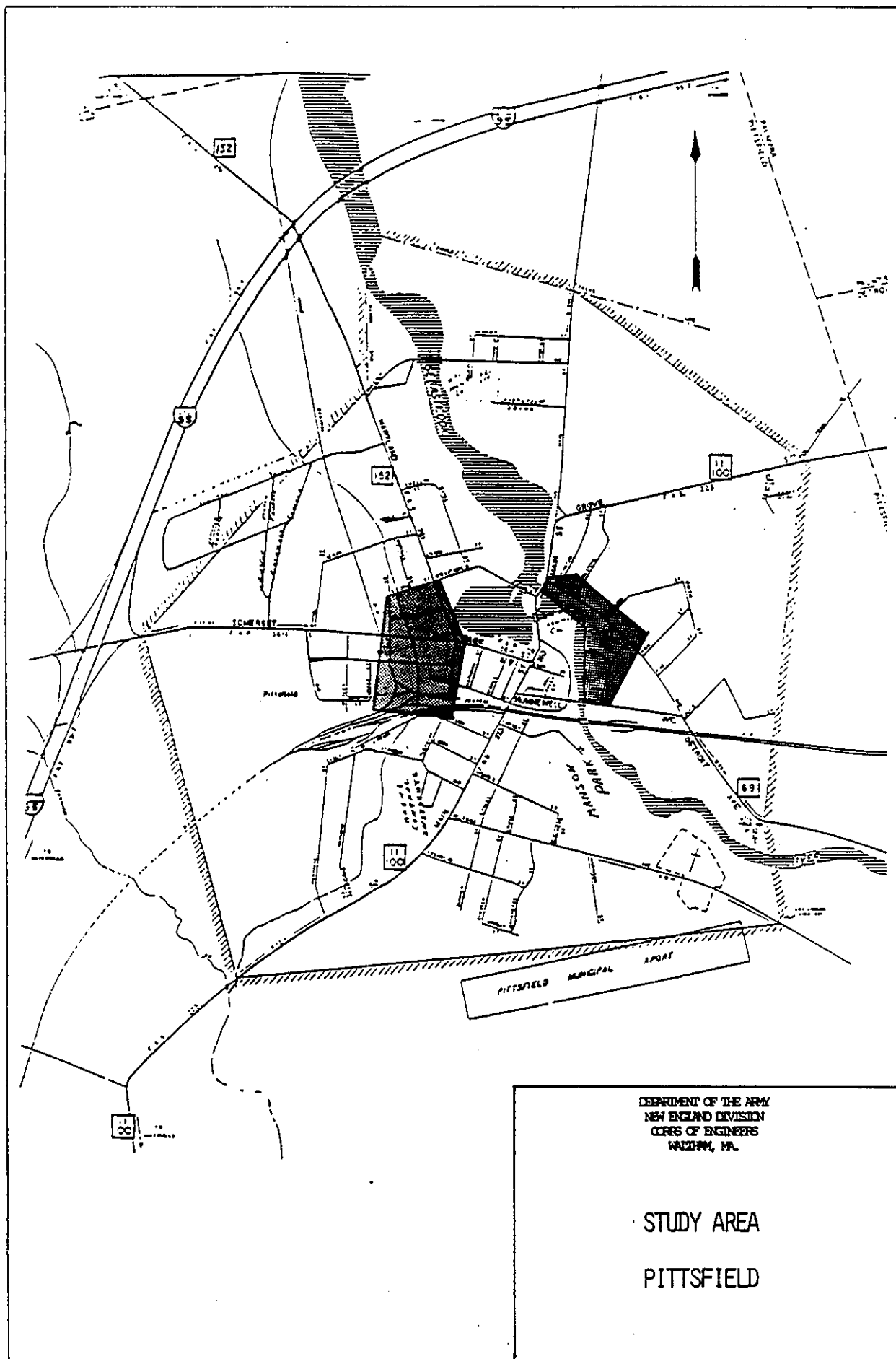
<u>Types of Structures</u>	<u>No. of Buildings</u>
Residential (wood) 1-1/2 stories or less	12
Residential (wood) 2 stories or more	20
Commercial/Storefront (masonry)	1
Commercial/Storefront (wood)	3
Public Works (masonry)	<u>1</u>
Total	37

Structural alternatives to flood protection were not evaluated because the length of protection required was not considered economically justified. A nonstructural plan providing closures for all the buildings was considered. Estimated construction costs and benefits for the proposed protection are shown below. The project cost was annualized over a 50 year period at 8-7/8 percent interest. As shown below, closures were found to be economically justified.

Nonstructural Improvement Plans - Pittsfield

	<u>Raising</u>	<u>Closures</u>
	(12 bldgs)	(37 bldgs)
Annual Benefits	\$16,500	\$69,300
Construction Cost	456,000	520,000
Annual Costs	49,300	47,000
Benefit/Cost Ratio	.33 to 1	1.47 to 1
Net Benefits	-	22,300

A summary of the structural and nonstructural local protection projects considered in the twelve communities studied are shown in Tables 15, 16, and 17.



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STUDY AREA

PITTSFIELD

TABLE 15

Economic Evaluation 100-Year Level Of Protection

<u>TOWN</u>	<u>LENGTH (FT)</u>	<u>FIRST \$COST</u>	<u>ANNUAL \$COST</u>	<u>ANNUAL \$BENEFITS</u>	<u>B/C RATIO</u>
AUGUSTA					
Dike	3,500	4,800,000	436,000	173,000	0.41
T-wall	3,500	12,100,000	1,100,000	173,000	0.16
HALLOWELL					
Dike	3,100	3,600,000	319,000	102,000	0.32
T-wall	3,100	8,400,000	746,000	102,000	0.14
GARDINER					
Dike	4,000	5,000,000	444,000	395,000	0.89
WATERVILLE					
Dike	1,400	1,600,000	142,000	54,000	0.38
WINSLOW					
Dike	3,000	4,500,000	399,000	104,000	0.26
T-wall	3,000	11,400,000	1,000,000	104,000	0.10
MADISON					
Increase height of dike & wall	800	760,000	67,000	42,000	0.63
SKOWHEGAN					
Dike	1,400	1,100,000	93,000	900	0.01
T-wall	1,400	2,000,000	175,000	900	0.00
FAIRFIELD					
Dike	4,500	5,500,000	491,000	23,000	0.05
T-wall	4,500	9,500,000	842,000	23,000	0.03
FARMINGTON					
Dike	1,600	965,000	86,000	49,000	0.57
T-wall	1,400	1,600,000	143,630	49,000	0.34

TABLE 16

Economic Evaluation 50-year Level Of Protection

<u>TOWN</u>	<u>LENGTH (FT)</u>	<u>FIRST \$COST</u>	<u>ANNUAL \$COST</u>	<u>ANNUAL \$BENEFITS</u>	<u>B/C RATIO</u>
AUGUSTA					
Dike	3,500	4,000,000	357,000	152,000	0.43
T-wall	3,550	9,300,000	822,000	152,000	0.18
HALLOWELL					
Dike	3,100	2,900,000	255,000	89,000	0.34
T-wall	3,070	6,000,000	536,000	89,000	0.16
GARDINER					
Dike	1,900	4,500,000	399,000	356,000	0.89
WATERVILLE					
Dike	1,400	1,200,000	109,000	31,000	0.28
WINSLOW					
Dike	3,100	3,400,000	299,000	73,000	0.24
T-wall	3,100	7,600,000	678,000	73,000	0.11
MADISON					
Has existing 50-year protection	-	-	-	-	
SKOWHEGAN					
Dike	1,400	600,000	51,000	100	0.00
T-wall	1,400	894,000	79,000	100	0.00
FAIRFIELD					
Dike	4,500	4,000,000	354,000	12,000	0.03
T-wall	4,500	6,300,000	558,000	12,000	0.02
FARMINGTON					
Dike	1,600	703,000	62,000	43,000	0.69
T-wall	1,400	1,100,000	100,000	43,000	0.43

TABLE 17

ECONOMIC EVALUATION, NONSTRUCTURAL ALTERNATIVES

<u>TOWN</u>	<u>FIRST COST</u>	<u>ANNUAL COST</u>	<u>ANNUAL BENEFITS</u>	<u>B/C RATIO</u>
HALLOWELL	\$2,800,000	254,000	256,000	1.01
WATERVILLE	893,000	80,000	12,000	0.15
WINSLOW	826,000	74,000	53,000	0.72
AUGUSTA	922,000	83,000	155,000	1.87
FAIRFIELD	775,000	70,000	18,000	0.26
PITTSFIELD	520,000	47,000	69,000	1.47
RANDOLPH	625,000	56,000	71,000	1.27
GARDINER	2,383,000	215,000	197,000	0.92
MADISON	185,000	17,000	43,000	2.52
SKOWHEGAN	1,254,000	113,000	17,000	0.15
FARMINGTON	752,000	68,000	75,000	1.10
ANSON	312,000	28,000	1,000	0.04

Environmental Considerations Of Local Protection Projects

Both general and site specific environmental considerations of the local protection projects investigated are discussed in Volume II of this report. The discussion presented is for information only since none of the structural alternatives (Walls/Dikes) were found to be economically justified.

Archaeological Considerations Of Local Protection Projects

Any structural alternative proposed for feasibility studies would require more research into the history and prehistory of the project area. This preliminary reconnaissance has revealed that the river's edge and floodplain have been intensively used by prehistoric and

historic peoples, and much evidence of their activities remains. These would need to be documented before any construction were to take place.

Non structural alternatives have a lesser potential impact to historic or prehistoric archaeological sites. However, floodproofing of structures in towns such as Gardiner and Hallowell, where the flooded structures are often within the bounds of National Register of Historic Districts, may have an effect on the integrity of the district. Non-structural solutions, including floodproofing, raising, and early warning systems, will have to be evaluated for their potential effect on these identified National Register properties. Close inter-agency cooperation will be required to arrive at the best solution for protecting the structures while maintaining their historic integrity.

AUTOMATED FLOOD WARNING SYSTEM

An automated flood warning system consists of a series of remotely located precipitation and/or stream flow gages that report to a computer. The computer gives information on predicted peak flood stage and the time to the peak stage. This information, through the application of a preparedness plan, can be translated into what would be expected to occur at individual communities in the Kennebec River Basin. Flood warning is not a solution to flooding; it can help reduce damages and potentially save lives.

Results of a cost analysis has shown that the benefits associated with the proposed flood warning system are sufficient to justify the project. The first time cost of the system is estimated to be \$642K. The cost was estimated using methods outlined in a 1984 Corps of Engineers study, "Flood Emergency Preparedness Systems", and with assistance from the National Weather Service. The estimated average forecast lead time for communities in the Kennebec Basin is 12 hours. Using this lead time, the Flood Emergency Preparedness study recommends using a maximum of 22 percent of the total annual damages as benefits for the flood warning system. This results in annual benefits of \$333K. Calculating the annual Cost based on a 15-year life at 8-7/8 percent results in a cost of \$67.2K. Along with an annual operation and maintenance cost of \$54K, the resulting benefit to cost ratio is 2.75 to 1.0. The components of the system and their associated costs are shown as follows.

<u>Component</u>	<u>Quantity</u>	<u>Cost</u>
Precipitation Gages	35	\$280,000
Stream Flow Gages	15	75,000
Computers	5	100,000
Communications (repeaters)	10	80,000
Sub-Total		535,000
20 % E&D		<u>107,000</u>
TOTAL		\$642,000

HYDROPOWER STORAGE RESERVOIR REREGULATION

In May 1988, The Corps of Engineers completed Part II of a hydrologic analysis of flooding in the Kennebec River Basin. The study was conducted under the authority contained in Section 22 of the Water Resources Act of 1972. A copy of this study is included in Volume II of this report. The study explored the development of reservoir regulation guidance which might further maximize the incidental flood reduction potential of the upper basin storage facilities, without impacting their hydropower function. All season reservoir regulation guide curves were developed by trial through multiyear sequential hydrologic system simulation. Simulations, using the developed guide curves, indicated that greater reservoir storage could be realized with little impact to the downstream flow regime. Storage capacity equivalent to six inches of runoff would be available about 65 percent of the time as compared to 40 percent under actual operations. Guide curve operation would likely minimize the spillage during nonspring refill floods, but would not completely prevent spillage during critical spring refill season floods such as the April 1983 and June 1984 floods. When abnormal spring runoff occurs spillage is inevitable. Therefore, secondary guidance was explored in a effort to modify peak discharge rates of spillage when spillage is eminent. Applying the guidance to the experienced April 1979, April 1983 and June 1984 flood events indicated potential reductions of about 30 percent in peak rates of spillage.

The study concluded that the adoption of monthly guide curves for the major storage reservoirs in the upper basin could reduce the effective runoff contribution from these watersheds. Based on the conclusion of the study, reregulation is recommended for additional study in a feasibility phase. Analysis in a feasibility phase will determine the benefits, costs and impacts associated with reregulation.

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

The Kennebec River experienced a major flood in March/April 1987. This was a new flood of record generally throughout the mid to lower Kennebec River Basin. Peak flows on the lower mainstem Kennebec and tributaries (Sandy, Carrabassett, and Sebasticook Rivers) ranged 20 to 30 percent greater during the spring 1987 event than the previous record flood of March 1936. Flooding occurred along the main stem Kennebec generally from Anson/Madison south to Gardiner/Randolph. In addition to flooding that occurred along the main stem Kennebec, flooding was experienced along the tributaries, Sandy and Sebasticook Rivers. Along the Sandy River, the community of Farmington was particularly hard hit while Pittsfield, located along the Sebasticook River, also experienced flood damage. The losses to communities in the basin during the 1987 event were estimated by the State of Maine to be \$34 million.

Due to the large size of the basin and the number of communities involved, it was decided to limit the investigation to communities that experienced \$500K or more in estimated damages during the 1987 event. Limiting the size of the study was necessary in order to provide meaningful information in the short timeframe of the study. The screening process resulted in the selection of fourteen communities for study. The damage estimates provided by the State were used for this screening process and damages in the communities selected account for over 90 percent of the total estimated damages. The communities selected were as follows.

Anson	Hartland	Randolph
Augusta	Hallowell	Skowhegan
Fairfield	Madison	Waterville
Farmington	Norridgewock	Winslow
Gardiner	Pittsfield	

The community of Hartland was not studied further since analysis revealed flood damages were the result of partial failure of a small dam, not overbank flooding. Norridgewock was dropped from further analysis after field investigations revealed only one structure in the 100-year floodplain.

Several alternatives were considered to prevent or reduce flood damages: flood control reservoirs, structural and nonstructural local protection projects, an automated flood warning system for the basin, and the adoption of monthly guide curves for the major storage reservoirs in the upper basin to reduce the effective runoff contributions from these watersheds.

Two flood control reservoir sites were investigated, one on the Sandy River and the other on the Carrabassett River. Results of economic analysis indicated that the projects were not economically justified. When acting in tandem these reservoirs would have reduced total average annual losses in the downstream communities by approximately 77 percent. Although there would be a significant reduction in annual losses, the annual cost of construction far outweighs the expected benefits.

Local protection projects were investigated in the 12 communities selected for plan formulation. The structural alternatives considered consisted of reinforced concrete flood walls and earthen dikes. The dikes and walls were evaluated at 50 and 100-year levels of protection. None of the structural local protection project alternatives investigated were found to be economically justified.

Nonstructural alternatives that consisted of a combination of raising structures where possible and installing closures for openings in the flood prone buildings were also investigated. Nonstructural alternatives were evaluated at a 100 year level of protection. Nonstructural plans were found to be economically justified in six of the twelve communities studied. The six communities are: Hallowell, Randolph, Augusta, Madison, Pittsfield and Farmington.

Results of the reconnaissance investigation showed that benefits associated with the proposed automated flood warning system are sufficient to justify the project. An economic evaluation resulted in a benefit to cost ratio of 2.8 to 1.0

In May 1988, the Corps of Engineers completed a hydrologic analysis of flooding in the Kennebec River Basin. This study was conducted under the authority contained in Section 22 of the Water Resource Act of 1972. The study explored the development of reservoir regulation which might further maximize the incidental flood reduction potential of the upper basin storage facilities, without impacting their hydropower functions. The study concluded that the adoption of monthly guide curves for the major storage reservoirs in the upper basin could reduce the effective runoff contributions from these watersheds. Based on that conclusion, reregulation is recommended for additional study to determine the associated benefits, costs and impacts.

In general, the reconnaissance investigation concluded that nonstructural measures involving raising structures and installing closures, an automated flood warning system, and reregulation of hydropower storage reservoirs appear cost effective. It is believed that a more detailed analysis of nonstructural plans may find incremental justification for portions of communities that in the reconnaissance phase did not appear economically justified.


RECOMMENDATIONS

Nonstructural measures involving raising structures and installing closures, an automated flood warning system, and reservoir reregulation appear cost effective and would normally be recommended for additional analysis in a feasibility study. However, since the estimated Federal portion of the first cost of the various alternatives that were economically justified are well within the \$5 million dollar Federal limit of Section 205 of the 1948 Flood Control Act, as amended, it is recommended that further studies be conducted under this authority.

In a letter, dated December 6, 1989, the State of Maine specifically requested that work continue under the authority of Section 205 of the 1948 Flood Control Act, as amended.

I, therefore, recommend that no further work be conducted in the Kennebec River Basin under this General Investigation Authority. Any further analysis may proceed under the existing Continuing Authorities Program.

23 JAN 90
Date


DANIEL M. WILSON
Colonel, Corps of Engineers
Division Engineer

APPENDIX - A

CORRESPONDENCE



United States Department of the Interior

FISH AND WILDLIFE SERVICE
400 RALPH PILL MARKETPLACE
22 BRIDGE STREET
CONCORD, NEW HAMPSHIRE 03301-4901

Mr. Joseph Ignazio, Chief
Planning Division
New England Division
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02254

SEP 10 1988

Dear Mr. Ignazio:

This planning aid letter is intended to provide a preliminary assessment of potential fish and wildlife impacts from several alternatives evaluated by the New England Division for the flood protection reconnaissance study of the Kennebec River Basin within Kennebec, Somerset, and Franklin Counties, Maine. It has been prepared under the authority of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.).

The reconnaissance investigation focuses on 14 communities with flood damages within the middle and lower portions of the Kennebec River Basin. These are: Anson, Madison, Skowhegan, Farmington, Hartland, Pittsfield, Norridgewock, Fairfield, Waterville, Winslow, Augusta, Hallowell, Randolph, and Gardiner. Two types of flood control measures are being examined for the Kennebec River reconnaissance study: structural measures to reduce flooding and non-structural measures to reduce or mitigate flood damages. Structural alternatives that would reduce flooding prior to reaching critical damage areas include two potential flood control reservoirs on the Carrabassett River and the Sandy River, both major tributaries within the middle Kennebec Basin. Structural measures that would reduce flooding at the critical flood damage areas include levees and floodwalls. The use of levees and/or floodwalls is being considered at 11 of the 14 flood damage areas: Anson, Madison, Skowhegan, Pittsfield, Fairfield, Waterville, Winslow, Augusta, Hallowell, Randolph, and Gardiner.

Non-structural flood control measures such as floodproofing buildings, flood insurance, and relocation of flood-prone structures (depending on the site where the structures are relocated to) usually do not cause significant adverse impacts to fish and wildlife resources. Non-structural flood control measures are preferred by the Fish and Wildlife Service due to their low level intensity of adverse impacts.

FISH AND WILDLIFE RESOURCES

The Kennebec River Basin lies in west-central Maine between the Androscoggin River Basin to the west and the Penobscot River Basin to the north and east. The river originates at Moosehead Lake near the U.S.-Canada border and flows approximately 145 miles south to Merrymeeting Bay where it meets the Androscoggin River. It then continues some 20 miles to the Atlantic Ocean.

The total area of the Basin is approximately 5870 square miles. The Kennebec River Basin is primarily forested (over 70 percent). Elevation ranges from over 4000 feet in the head waters to sea level at Augusta where the river becomes tidal.

Wildlife habitat at all of the communities where levees and floodwalls are being considered is generally limited to relatively narrow bands of riparian and wetland vegetation along the river's edge. All areas are affected by human disturbance to a certain degree, with some areas affected more than others. The primary habitat values of these riparian areas include: nesting and feeding habitat for migratory and resident birds; cover and movement corridors for small mammals, particularly fur bearers; and food production (i.e. terrestrial insects), shade, and cover for fish, particularly life stages that utilize shallow nearshore habitats.

Common mammals that could be expected to utilize the project areas include: raccoon, striped skunk, porcupine, red fox, river otter, mink, muskrat, beaver, snowshoe hare, eastern chipmunk, woodchuck, and gray and red squirrel. Small mammals such as shrews, mice and voles are likely common residents at most of the sites. Mammals likely found at the proposed reservoir sites would also include white-tailed deer, black bear, moose, bobcat, fisher and marten.

The project sites provide breeding, feeding, resting, and wintering habitat for a variety of bird species. Birds observed at the Kennebec study sites include: spotted sandpiper, great blue heron, mallard, black duck, common merganser, double-crested cormorant, herring gull, black-backed gull, belted kingfisher, common loon, American crow, blue jay, black-capped chickadee, cat bird, yellowthroat, American robin, song sparrow, yellow warbler, yellow-rumped warbler, winter wren, cedar waxwing, ruffed grouse, red-tailed hawk, and kestrel.

In accordance with Section 7 of the Endangered Species Act of 1973, as amended, (16 U.S.C 1561, et seq.), the Corps of Engineers is required to assure that their actions have taken into consideration impacts to Federally listed or proposed threatened or endangered species for all Federally funded, constructed, permitted, or licensed projects.

We have determined that listed species may be present within the proposed project area. The presence of both nesting and wintering bald eagles along the Kennebec River below Augusta was noted in our August 22, 1988, letter to the New England Division. The Corps responsibility to address impacts to threatened and endangered species associated with Federal projects is described in Sections 7(a) and (c) of the Endangered Species Act.

Important fishery resources in the Kennebec River Basin include smallmouth and largemouth bass, white and yellow perch, chain pickerel, brook, brown, and rainbow trout, and landlocked salmon. Important anadromous species are found in the lower Kennebec River below Edwards Dam in Augusta and in the Sebasticook River. These include: American shad, alewife, blueback herring, rainbow smelt, striped bass, and Atlantic salmon.

Shortnose sturgeon, Federally listed as endangered, are also found in the Kennebec below the Augusta dam. The Kennebec is important for sturgeon because the narrow channel and high flows combine to reduce salinity and provide spawning habitat for adults, while the lower river reaches provide brackish water favored by juveniles. Section 7 consultation for this species would be with the National Marine Fisheries Service.

Efforts currently underway to restore Atlantic salmon, alewife, and American shad are described in the document entitled "Lower Kennebec River Anadromous Fish Restoration Plan and Inland Fisheries Overview" prepared by the Maine Department of Marine Resources, Department of Inland Fisheries and Wildlife, and Atlantic Salmon Commission. Once targeted restoration goals are met, Atlantic salmon would be present at all of the Kennebec River study sites. Shad and alewives would be present at all of the study sites below Madison.

Historically, the Kennebec River Basin, particularly the Sebasticook River and lower mainstem Kennebec, has suffered from poor water quality due to municipal and industrial discharges, combined sewer overflows, and nonpoint source pollution. Water quality has dramatically improved since the 1970's with the construction of new wastewater treatment facilities within the Basin. Water quality is no longer considered a major factor limiting the restoration of anadromous fish in the Basin. While problem areas still exist, it appears that designated water quality standards are currently being met for all river segments included in this reconnaissance study.

HABITAT CONDITIONS OF THE STUDY SITES

Carrabassett River

The Carrabassett River, with a total drainage area of 400 square miles, is a major tributary that joins the Kennebec at North Anson. All 45 miles of the Carrabassett River have been included in the Nationwide Rivers Inventory for possible designation as a Wild and Scenic River. Its designation as a category "B" river in the Maine Rivers Study denotes composite natural and recreational resource values with outstanding statewide significance. Significant attributes identified in the Rivers Study include: geologic-hydrologic, critical/ecologic, inland fishery, whitewater boating, canoe touring, and historic resource values.

The proposed dam site on the Carrabassett River lies about 7 miles up from the mouth at elevation 330 msl, just below the town of East New Portland. The maximum extent of reservoir inundation at full pool would cover approximately 7189 acres, including: approximately 5 miles of the Carrabassett River, 2 miles of Hutchins Brook, 1 mile of Harris Brook, 1.5 miles of Meadow Brook, 2 miles of Clark Brook, 4.5 miles of Gilman Stream, 790 acre Gilman Pond, 5 miles of Alder Brook, and approximately 8 miles of Sandy Stream.

The primary cover type in the impoundment area is mixed deciduous/coniferous forest with species such as white pine, red oak, eastern hemlock, red, silver and sugar maple, American larch, black cherry, and American beech. The Carrabassett River channel is braided in places and the islands support mature stands of riparian hardwood forests with box elder, red maple, white, yellow, and gray birch, choke cherry, balsam poplar, and red-osier dogwood.

Within the proposed impoundment area, there are extensive wetlands in the region known as Lexington Flats, which includes Gilman Stream, Gilman Pond, Sandy Stream, and Alder Brook. South of Gilman Pond the wetlands appear to be primarily red maple swamps. There are extensive areas of emergent wetlands, most vegetated with sedges, associated with the northern reaches of the pond. Moving north into the Sandy Stream and Alder Brook drainages, there are hundreds of acres of interspersed forested, shrub-scrub, and emergent wetlands. The forested wetlands are hummocky and include red maple, northern white cedar, black spruce, black ash, hemlock, and balsam fir. The shrub-scrub wetlands are mostly dense thickets of speckled alder and gray birch. Emergent wetlands contain mostly sedges, many with standing snags. Other plants observed among these three wetland types include: spirea, sweet gale, hobblebush, raspberry, lambkill, alder buckthorn, elderberry, choke cherry, galium, false solomon's seal, sedge spp., marsh cinquefoil, soft rush, blue flag, and sensitive, cinnamon, royal, and ostrich fern.

The Carrabassett impoundment area also includes agricultural land, residential development, and two small towns--North and East New Portland.

The Carrabassett River Basin contains high quality habitat for a variety of wildlife. The extensive wetland areas in the Gilman Pond drainage are good producers of waterfowl such as wood duck, black duck, and possibly merganser and goldeneye. The entire basin provides summer habitat for big game species such as black bear, moose, and white-tailed deer. There are deer wintering areas in the upper reaches of Sandy Stream and Alder Brook. Gilman Pond hosts nesting common loons and is also a Canada goose release site.

Aquatic habitat conditions in the Carrabassett River are excellent with extensive gravel riffles and side channels. Recreationally important fish species in the Basin include: smallmouth bass, brook trout, brown trout, pickerel, yellow perch, sunfish, and brown bullhead. Gilman Pond and its tributaries support significant natural populations of brown and brook trout due to the exclusion of competing smallmouth bass by the Gilman Stream hydro dam downstream.

Atlantic salmon are also a species of concern within the Carrabassett Basin. State and Federal fishery management agencies have developed plans to eventually restore Atlantic salmon to their historic range within the Kennebec Basin, which includes the Carrabassett River.

Sandy River

With a total drainage area of 593 miles, the Sandy River is a lower gradient tributary than the Carrabassett, falling 1544 feet over its 69-mile length (as compared to the Carrabassett River which falls 2483 feet over its 45-mile length). The Sandy River joins the Kennebec River about 2.5 miles below the towns of Anson and Madison.

The Sandy River was also designated as a category "B" river in the Maine Rivers Study, denoting outstanding statewide significance for geologic-hydrologic, critical/ecologic, scenic, inland fishery, whitewater boating, and canoe touring resource values.

The proposed dam site on the Sandy River is located approximately 10 miles from the mouth at elevation 200 feet. This is the site of the Greenleaf Dam previously identified in the 1950's New England-New York Inter-Agency Committee comprehensive resource report. The impoundment at full pool, encompassing about 4520 acres, would extend upstream from the dam approximately 16 miles. It would also inundate about 3 miles of Josiah Brook and a mile of Fillibrown Brook. Lemon Brook would be affected as the lower four miles of the Lemon Brook channel would be used to route spillway flows back to the Sandy River.

The Sandy River valley affected by the flood control reservoir is covered with a mosaic of deciduous and mixed forest and prime agricultural land. Forest tree species include red oak, red, silver and sugar maple, ash, box elder, white, yellow and gray birch, black cherry, white pine, eastern hemlock, quaking aspen, balsam poplar, and American beech.

The impact area does not contain large tracts of wetlands like in the Carrabassett Basin, but riverine and palustrine wetlands are present along the river channel. Riparian and wetland plants include speckled alder, spirea, red-osier dogwood, willow, honeysuckle, Joe-Pye-weed, arrowwood, and wild-raisin.

Wildlife habitat in the Sandy River valley is of very high quality due to the interspersed cover types and the presence of highly productive bottomland hardwood forests. Summer range for big game is excellent. The basin provides breeding, resting and feeding habitat for a variety of waterfowl. Black duck and Canada geese are among the species that stopover on agricultural fields during the fall migration. Mallards, black duck, and mergansers are among the breeding waterfowl. Woodcock are important game birds. A number of raptors occur within the basin, including red-tailed, broad-winged, and red-shouldered hawks, and the kestrel. There is the possibility of use year-round by bald eagles. Peregrine falcons have been observed passing through the basin.

The Sandy River offers a wide range of aquatic habitat conditions throughout the affected reach. The river bottom is quite productive and provides a substantial food base for fish resources. Lemon Stream supports a seasonal cold water fishery.

The most abundant game fish species in the lower reaches of the Sandy River is the smallmouth bass. Brown and brook trout are more common in the upper reaches. These are natural production fisheries--stocking has been discontinued. Catadromous American eels are able to pass downstream dams on the Kennebec River and are common in the Sandy River. Anadromous fish restoration plans are dependent on substantial habitat contributions by the Sandy River. The Sandy has the highest nursery potential for Atlantic salmon of any of the mainstem or tributary areas of the Kennebec. The shad restoration plan assumes there will be shad production in the Sandy River from the mouth to Farmington.

Anson

Structural flood control measures under consideration for the town of Anson would be limited to raising an existing concrete retaining wall along the Kennebec River immediately below the Route 201 bridge. There is a narrow band of grass with several ornamental spruce trees between the highway and the river that could be affected by raising the wall. The site presently has no important fish or wildlife habitat features that would be affected by the project.

Madison

Under consideration in Madison are one or more dikes and/or walls in the vicinity of Cooper Industries and the Madison Paper Company. The Madison Paper Company site below the Route 201 bridge has been extensively walled and riprapped in the past and habitat is presently poor. The other site in Madison, upstream of the Route 201 bridge at Cooper Industries, would involve raising 100-200 feet of existing concrete and earth-covered sheetpile

walls. The earth-covered wall is maintained as a grassy picnic area and has little wildlife habitat value. There is a 10- to 12-foot-wide band of shrubs along the river including: staghorn sumac, speckled alder, gray birch, poison ivy, ash, nightshade, raspberry, goldenrod, burdock, and milkweed. This strip of vegetation provides limited cover for small birds and mammals and aquatic animals along the edge of the river.

Skowhegan

The primary flood control alternative at Skowhegan involves operational changes at the existing hydropower facility to reduce backwater elevations during high flow events. This should not impact fish or wildlife habitat.

Also under consideration is the construction of a small dike, about 200 feet long, to prevent flood flows from spilling over the river bank and entering a residential area in the vicinity of Elm Street. The dike would be located in a vacant residential lot that is bordered by a small stream. The lot is overgrown with bracken fern, goldenrod, milkweed, wild carrot, and raspberry. There is a wetland border along the river's edge that includes cattails, sedges, pickerel weed, red-osier dogwood, and Joe-Pye-weed. The stream channel has dense riparian cover with sugar maple, ash, willow, box elder, black cherry, jewelweed, nightshade, Virginia creeper, and buttercup.

Pittsfield

The primary flood control structure being considered for Pittsfield is a levee along the Sebasticook River. The structure would extend about 2000 feet from the dam just below Main Street to the Hunnewell Avenue bridge. The Sebasticook River here flows over bedrock ledges in the upper portion of the segment, changing to large cobble and rubble about 1000 feet below the dam. Midway through the reach, there is a backwater area with pondweed and algae growth. Freshwater mussel shells are numerous, a likely indication of muskrat presence.

Bordering the river along the entire reach is a 10- to 50-foot-wide wooded riparian zone. Overstory species here include red maple, ash, box elder, silver maple, red oak, and choke cherry. There is a well developed understory, very dense in places, consisting of arrowwood, silky and red-osier dogwood, alder-buckthorn, honeysuckle, and wild rose. Ground cover includes: wood sorrel, barberry, galium, gooseberry, Virginia creeper, royal fern, raspberry, and sensitive fern.

The Sebasticook River plays a role in the state's anadromous fish restoration plans for the Kennebec River Basin. Alewives are currently being stocked in the Sebasticook Basin. The river offers primarily a warmwater fishery for bass, black crappie, and perch. It is seasonally important for cold-water species like brown and brook trout.

Fairfield

Structural flood control at Fairfield would likely involve a levee along the Kennebec River in the vicinity of Upper Main Street. Depending on the level of protection provided, the structure could be between 250 and 4000 feet-long. Due to the close proximity of structures to the river in this vicinity, a levee would probably be located directly adjacent to the river, possibly encroaching into the water in places.

With the exception of a few small patches of lawn, there is a band of riparian vegetation along the 4000-foot-long study reach. The riparian zone varies from 10 to 40 feet wide. Vegetation is also variable. The upper segment contains dense woody vegetation that hangs out over the river, providing excellent fish and wildlife habitat conditions. Tree species here include willow, silver maple, red oak, elm, ash, and box elder. Understory plants are primarily red-osier dogwood, japanese knotweed, Virginia creeper, grape, raspberry and staghorn sumac. Herbaceous species include milkweed, grape, raspberry, Joe-Pye-weed, goldenrod, ostrich fern, sensitive fern, jewelweed, nettle, Virginia Creeper, burdock, and nightshade. The lower (downstream) portion of the study area contains many of the same species (quaking aspen is also present) but the understory has been cleared and overhanging vegetation is absent. There are also areas where maintained lawns extend to the waters edge.

Islands in the Fairfield vicinity offer good waterfowl breeding habitat. They also receive seasonal use by waterfowl, cormorants, gulls, and other migratory birds.

This reach of the Kennebec River is stocked with brown trout by the Department of Inland Fisheries and Wildlife. The primary fishery in this reach is for smallmouth bass and brown trout.

Waterville

The Waterville study site includes the area immediately downstream of the Central Maine Power Company's hydropower facility at the Waterville dam. Structural flood control measures here could include a levee extending from the dam abutment to a point approximately 1000 to 2000 feet downstream. Depending on the final alignment, much of the levee could be located on ground

that has already been raised and armored for flood protection and is currently used as a parking lot. However, it is likely that some portion of the structure would encroach on a forested wetland to the south of the parking lot. The wetland includes species such as red and silver maple, box elder, ash, willow, red-osier dogwood, arrowwood, Joe-Pye-weed, and jewelweed.

This reach of the Kennebec River is an important nursery area for brown trout, which are stocked annually by Inland Fisheries and Wildlife. The area's existing popularity for angling may further increase with expected changes to the dam that would direct more flow towards the west bank of the river.

Winslow

The Winslow study site is located at the confluence of the Sebec and Kennebec Rivers. Structural protection here would involve a levee extending approximately 2000 feet along the Sebec and Kennebec River banks. Structures built here would be located on the narrow strip of land between Lithgow Street and the river's edge; the former site of a number of residences washed away during the 1987 flood.

The site now contains sparse tree cover of species such as ash, willow, box elder, and sugar maple. The understory consists of pioneering plants that have invaded the disturbed residential lots. Species include burdock, ragweed, thistle, goldenrod, butter and eggs, wild carrot, nightshade, Virginia creeper, and wild rose. Red-osier dogwood, Joe-Pye-weed, and jewelweed are found on the river banks.

There is a popular fishery for brown trout and smallmouth bass along the bank at Winslow.

Augusta

Two sites in Augusta are possible candidates for levees and floodwalls. The primary site is along the west bank of the Kennebec from Bond Brook down to Memorial Bridge. There is little wildlife habitat value here as the entire area is heavily developed. The river banks are for the most part armored with heavy riprap. Patches of shrubby box elder, willow, and silver maple occur in several places along the bank. There is a stand of riparian vegetation about 20 feet wide at the mouth of Bond Brook that extends downstream about 200 feet. It is comprised of elm, box elder, willow, grape, purple loosestrife, and Japanese knotweed.

The other study site in Augusta is on the east bank, in the vicinity of the old town hall. There is a narrow band of vegetation along the riverbank here. Species include willow, black locust, box elder, grape, raspberry, goldenrod and Japanese knotweed.

Tidal influence extends up to the dam in Augusta, and at low tide sea birds and waterfowl feed on the exposed intertidal flats. Birds also winter on this segment of the Kennebec River; notable species include the black duck and bald eagle.

Augusta is an important area for fishery resources. Smelt and shad spawn in the river, and possibly striped bass. There is a recreational fishery for white perch, striped bass, Atlantic salmon, shad, brown trout, and smelt. Spring fishing from the river's west bank in Augusta has been described as "intense." Bond Brook offers spawning and rearing habitat for brown and brook trout and Atlantic salmon. Bond Brook also provides important cold water refuge habitat for salmonids when temperatures in the Kennebec become stressful.

Hallowell

Flood protection for the town of Hallowell would involve a floodwall, levee, or combination of the two along the entire waterfront area. The structure would likely be 20 to 25 feet tall and 3000 to 4000 feet long. Habitat value in the area is limited due to existing development and previous filling along the river. Much of the site is covered by parking spaces and grassed parkland. There are small patches of shrubs and trees that provide nesting habitat for passerine birds. Vegetation along the river bank includes willow, box elder, knotweed, red-osier dogwood, elm, ash, St. John's-wort, yarrow, galium, clover, nightshade, wild rose, grape, and raspberry.

Significant resources include: smelt spawning in the mainstem, a winter fishery on smelt, significant shorebird use on intertidal flats, and juvenile salmon rearing in nearby Vaughn Brook.

Gardiner

Construction of a 4000- to 5000-foot-long levee along the waterfront is being considered to protect the Town of Gardiner from flooding. The site is bisected by Cobbosseecontee Stream, which would necessitate some type of outlet structure in the levee. Over half of the study site has been substantially altered in the past, resulting in low habitat value for wildlife. The shoreline in the altered reach has been riprapped or bulkheaded and is sparsely vegetated. There is about 1000 feet of natural shoreline at the north end of the study site. Vegetation here is limited to a narrow band of riparian vegetation sandwiched between the river and railroad tracks to the west. Plant species include: ash, box elder, sugar maple, red-osier dogwood, speckled alder, honeysuckle, Joe-Pye-weed, and purple loosestrife.

There is a significant fishery for striped bass in the Kennebec at Gardiner. The Cobbosseecontee Stream drainage is designated in the anadromous fish restoration plan for early restoration of alewives. Cobbosseecontee Stream provides spawning and rearing habitat for salmon, brown trout, shad, smelt, and alewives.

Randolph

The Randolph study site is located across the river from Gardiner. A possible structural solution would involve a small dike or wall along the river to protect the downtown area. As a result of waterfront development, habitat value in the central part of town is limited to several small stands of trees, primarily box elder, ash, and black locust. However, in the reach between the center of town and Togus Stream, there are several high quality shrub-scrub and emergent wetlands along the river that would be adversely affected if the levee were extended to protect outlying areas.

Togus Stream provides excellent spawning and rearing habitat for salmonids. It is targeted for future alewife restoration in the anadromous fish restoration plan.

POTENTIAL PROJECT IMPACTS

Levees and Flood Walls

The primary impacts of levee and floodwall construction would include: the direct physical loss of habitat from construction of the structures, construction-related impacts to habitat and water quality, and loss of waterfront access and angling opportunities.

Construction of floodwalls and/or levees at some of the study sites could eliminate shallow-water rearing habitat, overhanging bank cover, riparian habitat, and wetlands. Impacts would extend beyond the actual footprint of the levee or floodwall if they prevent seasonal high flows from recharging adjacent wetland or riparian areas. Because of their high habitat value and the difficulty in developing successful mitigation, we would recommend against the construction of levees and floodwalls within shallow water habitats, wetlands, or streamside riparian buffers.

Of the 11 communities where levees and/or floodwalls are under consideration, Anson, Madison, and Skowhegan have the lowest potential for impacts to fish and wildlife resources. Structures at Pittsfield, Winslow, Fairfield, and Augusta have the potential to encroach on the river channel due the lack of setback space. Habitat encroachment may occur at Hallowell, Gardiner, Randolph, and Waterville, depending on the final siting of the structures.

In addition to direct habitat losses from construction of the flood control structures, wildlife utilizing adjacent habitats would be displaced during disruptive construction activities. Depending on the season and length of the construction period, displacement may lead to direct mortality due to nest abandonment or dispersal-related losses (predation, competition, road kill, etc.). This disturbance factor would apply to all structural flood control measures. Although disturbance cannot be eliminated, mortality associated with nest failure can be reduced by scheduling all construction activities for the late summer and fall months.

One of the primary concerns of the Maine fish and wildlife management agencies is the need to maintain and enhance public access for fishing along the Kennebec River. Levees and floodwalls have the potential to cutoff access to the river, depending on their location and design. The study sites with the greatest potential for impacts to fishing access are: Randolph, Gardiner, Hallowell, Augusta, Fairfield, Winslow, and Waterville.

Fish passage is a concern where levees would cross the mouth of streams. Levees or walls have the potential to affect fish passage at the mouth of Cobbosseecontee Stream and Bond Brook. Fish passage conditions at these and any other sites where structures would cross streams should be evaluated during the detailed project review phase.

Due to the degree of uncertainty regarding the actual design and siting of levees and floodwalls, we will need to review more specific project design information before we can fully evaluate the impact of any of these local protection projects. Before mitigation measures can be developed, more detailed habitat evaluations of affected areas for target species may be required.

New Reservoir Construction

The construction of new flood storage reservoirs on the Carrabassett and Sandy Rivers would cause significant adverse impacts to fish and wildlife resources. Permanent habitat loss from the footprint of the earthfill dams would range from 35 to 55 acres at each dam. There would be additional permanent habitat losses from construction of access roads, maintenance facilities, and containment dikes at the Sandy River site.

The current proposal is for "dry bed" reservoirs that would not include a permanent impoundment. However, there would be significant habitat changes associated with clearing the storage area to the elevation needed to store a runoff event with a five-year recurrence interval. Maintenance of this area in an early successional stage would essentially eliminate the existing terrestrial and aquatic habitat values associated with streamside wetlands and riparian forests. High quality agricultural lands that are valuable to wildlife may also be affected by reservoir clearing in the Sandy River basin.

Physical habitat changes can also be expected from the impoundment of water behind the dams. The magnitude of habitat impacts will depend on the area flooded and water residence time in a given year. Temporary flooding can cause both direct mortality of vegetation or delayed mortality resulting from chronic water stress. Plant communities would eventually change with the imposition of different ground and surface water regimes. New wetlands could eventually develop where water is ponded, however, it is doubtful that quality habitat areas would be formed due to the irregular fluctuation of water levels.

Impacts to wildlife would not be limited to the acreage of habitat cleared or flooded. Entire populations of animals in a basin, particularly big game, could be affected by the loss of cover along seasonal migration routes traditionally provided by riparian corridors. The loss of seasonal foraging habitat would similarly affect animal populations that are not year-round residents in the impact zone.

Annual flooding of the impoundment area would also impact wildlife production levels. Animals nesting on the ground or in the shrub layer would be particularly vulnerable to nest or brood loss from inundation. Arboreal species may be affected directly by inundation, or by the loss of canopy cover associated with water stress.

Fishery resources would also be negatively affected by the construction and operation of flood control reservoirs on the Sandy and Carrabassett Rivers. Among the direct aquatic habitat impacts would be the loss of cover, shade, and terrestrial food inputs from the removal of the streamside vegetation. Substrate suitability for spawning and food production would be reduced as a result of sediment deposition behind the dam. This problem would be particularly pronounced in the Sandy River as it carries a very high level of bedload material. Additional sediment sources may develop from the loss of vegetative cover and periodic flooding of the impoundment area. Increased sediment levels can adversely affect fish eggs, fish gills, and can reduce habitat quality by filling in pools and smothering productive riffles.

Impacts to aquatic habitat downstream of the impoundments could also be expected. Substrate suitability for spawning and food production may be reduced if gravel recruitment is interrupted by the dams. Water turbidity and sediment levels may increase if fine material accumulated behind the dams is transported downstream with the release of stored flood waters. Effects on other water quality parameters are difficult to evaluate until more specific information on the design and operation of the projects is available.

Fishery habitat would be affected by instream flow changes upstream and downstream of the dams. In the impoundment areas, free flowing riverine habitat would be converted to slow moving lake habitat during periods of water storage. Natural flow levels below the dams would be decreased during periods of storage and increased when stored water is released. Fluctuating flow levels can cause fish stranding, redd dewatering, and can affect habitat levels for all life stages of fish. We recommend that detailed instream flow investigations using assessment techniques such as the Fish and Wildlife Service's Instream Flow Incremental Methodology be conducted to evaluate flow-related impacts and develop mitigative measures.

An obvious impact of dam construction would be to fish passage. The dams would affect the seasonal movement patterns of existing resident fish as well as the migration of anadromous species slated for restoration in both the Sandy and Carrabassett River basins. Even with the addition of state-of-the-art fish passage facilities, there would be some incremental affect to anadromous fish movement since no facility is completely effective. Studies of fishway design will be necessary during the detailed project review process.

A major concern expressed by the Maine Department of Inland Fisheries and Wildlife would be the loss of the high quality trout fishery in Gilman Pond and its tributaries from the introduction of smallmouth bass and other predatory fish. These competing species are currently excluded from the drainage by the Gilman Stream hydropower dam which would be inundated by the Carrabassett River impoundment.

Lemon Stream would be used to convey water from the emergency spillway back to the Sandy River. Impacts to habitat and biota in Lemon Stream cannot be evaluated until additional information on the expected physical changes to the Lemon Stream channel are available.

Nonstructural Measures

The use of nonstructural measures to prevent flood damage would, for the most part, not impact the fish and wildlife resources of the Kennebec River. The only possibility of habitat degradation from nonstructural measures would be if houses or other structures were relocated to areas currently occupied by wetlands or other wildlife habitat areas that are currently undeveloped.

SUMMARY

Most of the structural alternatives for flood control in the Kennebec River study area have the potential to cause adverse impacts to fish and wildlife resources. We recommend that nonstructural measures be investigated to accomplish flood control objectives on the Kennebec River and its tributaries because they offer a solution that is essentially free of impacts to natural environmental features.

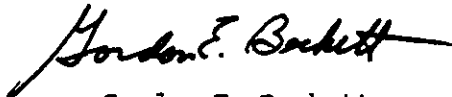
Potential impacts associated with the construction of levees and floodwalls in 11 flood prone communities would be the direct loss of shallow water habitat, wetlands, and riparian habitat; water quality degradation and wildlife disturbance/mortality associated with construction activities; impacts to waterfront access for angling; and impacts to fish passage where structures cross tributary streams. We recommend that more detailed fish and wildlife impact analyses be performed once specific local protection plan designs are available. Habitat evaluations for target species and additional coordination with state fish and wildlife management agencies will be needed for development of mitigative measures.

The construction and operation of flood control dams on the Carrabassett and Sandy rivers would result in major adverse impacts to fish and wildlife resources of national significance. Successful mitigation would be difficult or impossible to achieve for a number of impacts, particularly the loss of prime bottomland forest habitat and agricultural land. We recommend that both dam construction alternatives be dropped from further consideration.

If further investigations of dam feasibility are considered, we recommend that detailed studies be performed to assess the full impact of the projects on fish and wildlife. Such studies would include, but not be limited to: an evaluation of all affected terrestrial and aquatic habitat, preferably using the Service's Habitat Evaluation Procedures; development of fish passage design criteria for both dams; instream flow studies using the Instream Flow Incremental Methodology; and development of mitigation measures.

Thank you for the opportunity to provide these planning aid comments. If you have any questions regarding this letter, please contact Michael Tehan of my staff at (603) 225-1411 or FTS 834-4411.

Sincerely yours,

A handwritten signature in black ink, reading "Gordon E. Beckett". The signature is fluid and cursive, with a long horizontal stroke extending to the right.

Gordon E. Beckett
Supervisor
New England Area

CC: RO/FWE Reading File
ME IFW, Ray DeSandre & Peter Cross
RFD #3, Farmington, ME 04938
ME IFW, Augusta, Gene Dumont & Dennis McNeish
ME IFW, Augusta, Steve Timpano
ME DMR, Augusta, Tom Squiers, Jr.
ME Atlantic Sea-Run Salmon Comm. Ken Beland
FWE: MTehan:bjh:9-19-88:834-4411



John R. McKernan, Jr.
Governor

Lynn Wachtel
Commissioner

Kathryn J. Rand
Deputy Commissioner

Department
of
ECONOMIC AND COMMUNITY DEVELOPMENT
OFFICE OF COMPREHENSIVE PLANNING

December 6, 1989

Joseph L. Ignazio
Chief, Planning Division
New England Div., Corps of Engineers
424 Trapelo Road
Waltham, MA 02254-9194


Dear Mr. Ignazio,

The purpose of this letter is to express our interest in continuing to work with the New England Division in implementing recommendations of the Reconnaissance Report on the Water Resource Study for the Kennebec River Basin. Specifically, we are interested in exploring the possibility of continued studies and funding pursuant to Section 205 of the Flood Control Act of 1948.

As you may know, Maine experienced heavy rains and severe washouts and flooding this Spring resulting in a federal disaster declaration. Federal funding may exist through a recently authorized Hazard Mitigation Program at the Federal Emergency Management Agency to assist our efforts at establishing an effective state-wide flood warning system. We are encouraged by the prospect that a joint effort on the part of the affected communities, the State of Maine, the Army Corps, the Federal Emergency Management Agency, the U.S. Geological Survey, and other appropriate federal agencies can lead to successful implementation of the Reconnaissance Study recommendations.

John DelVecchio, of my staff, will contact you in the near future to initiate negotiations for participating in the Army Corps Section 205 Continuing Authority Program.

Sincerely,



Lynn Wachtel
Commissioner

cc: Richard Silkman
Governor McKernan

LW/JD/kg